CHANGING SOURCES OF FARM OUTPUT

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CONTENTS

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CHANGING SOURCES OF FARM OUTPUT

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SUMMARY AND CONCLUSIONS

Except for interruptions during the drought and depression period of the 1930's, the volume of farm output for human use has trended consistently upward in the United States since 1870. Farm output in 1955, for example, was nearly five times the output 85 years previously. This long-term expansion in the production of food, fiber, and tobacco occurred in response to growth in market demand at home and abroad. Population increased more than fourfold during this period, and a much larger population is now better fed. The volume of exports in the mid-1950's was four times that of 1870. In recent years, however, farm output has increased faster than growth in market demand. This tendency toward overproduction of agricultural commodities has depressed farm prices and created major adjustment problems.

What were the major sources of this increase in farm output for human use? This discussion is directed chiefly toward an attempt to answer this question. Sources of changes in farm output from the end of World War I to 1955 are emphasized.

Expansion of the physical cropland base was the major factor in the growth of output during the half century between the end of the Civil War and the beginning of World War I. The total acreage of cropland, farm output, and farm-produced power of horses and mules were each about three times as large in 1920 as in 1870.

The increase in the cropland base occurred largely in response to the Government homestead policy, improvements in our transportation system, and growth in demand for food, fiber, and tobacco at home and abroad. The additions to cropland also made it possible to produce the hay and grain needed to feed the growing number of horses and mules that provided the major source of power needed for the expanding agriculture of the period.

A marked change in the source of the greater output occurred during the interwar years. Farm output increased by 22 percent and at an annual rate of 0.77 index points (1947-49 = 100). Cropland was a relatively unimportant source of change in farm output. The acreage of cropland for the Nation was about the same at the beginning of World War II as at the end of World War I.

The major source of greater output during the interwar period was the shift in the kind of power used by farmers. As tractors, motortrucks, and automobiles replaced horses and mules as a source of power, vast acreages of crop and pastureland and large amounts of labor and other resources were released from raising feed for horses and mules to the production of products for human use. This direct effect of mechanization accounted for half the rise in farm output from 1919-21 to 1938-40.

Crop production per acre trended upward during the interwar period as a whole, except for the interruption in the 1930's caused by economic depression and drought. Stepped-up outturn of crops per acre was the second main source of additional farm output. Crop production per acre increased 9 percent as a result of using more fertilizer, improved seed, more irrigation, and other improved and more timely practices. Weather was not so favorable at the end of the interwar period as it was at the beginning. Thus, weather tended to decrease crop production per acre and farm output during this period.

Use of commercial fertilizer increased from less than a million tons of plant nutrients in 1919-21 to about 1.5 million tons in 1938-40. Fertilizer may have accounted for around a tenth of the total change in farm output during this period, or as much as the increase from irrigation and hybrid corn combined.

A greater volume of product added by livestock (production added in the conversion of feed and pasture into livestock and livestock products) ranked third as a source of expanded output in the interwar period. Livestock productivity made important strides. Average livestock production per breeding unit--milk per cow, eggs per hen, and so on--rose by more than a third. In general, improved breeds, heavier feeding of better-balanced rations, sanitation, and advances in management were among the more important factors behind this step-up in output per animal. As with crop

production per acre, economic depression and drought interrupted the upward trend in livestock production per breeding unit during the midthirties.

The total amount of pasture consumed by all livestock changed little from 1919-21 to 1938-40. However, the decrease in the number of farm horses and mules as a result of mechanization made available adequate quantities of pasture for expansion in the production of meat, milk, and other food livestock products.

The decade and a half following 1940 was a period of revolution in farming methods and production. The rapid growth in demand during World War II and in the immediate postwar years provided economic incentives to farmers to accelerate adoption of improved production methods that were developed largely during the interwar period. Farm output increased by one-third and at an annual rate of 1.90 index points--a substantial step-up over the rate of 0.77 index points during the previous two decades.

The shift in kind of power continued to be an important source of increase in farm output from 1940 to 1955. The average yearly addition to farm output from mechanical power was about the same as in the earlier period. But in terms of relative importance as a source of stepped-up output during World War II and the postwar years, it ranked third. The shift from animal to mechanical power was relatively complete by the midfifties.

A greatly expanded production of feed crops formed the basis for an increase of a third in livestock production from 1940 to 1955. Both number of breeding units and production per unit rose greatly. As a result, the average annual increase in product added by livestock was four times as large as in the interwar period. The expansion in product added was the second most important source of additional farm output during the years of World War II and the immediate postwar years.

As in the interwar period, the total acreage of cropland changed little. It increased only 4 percent for the entire United States from 1940 to 1955. However, substantial changes in cropland area were made in the broad geographic divisions of the country--northeastern, north-central, southern and western. The northeast and the southern divisions recorded decreases of 10 to 25 percent, while the north-central and western divisions had increases ranging from 10 to 40 percent. On the whole, average crop production per acre was higher in the divisions that had had decreases in cropland and lower in those that had expanded cropland acreages. Thus, the change in the proportion of the total acreage of cropland located in divisions of lower than average crop outturn per acre had a negative effect on overall crop production per acre.

Increases in crop production per acre dominated the growth in farm production from 1940 to 1955. More than 40 percent of the increase in total farm output came from this source. Average crop production per acre increased about 20 percent. The yield per acre of some of the leading crops increased greatly. Favorable cost-price relationships throughout the period were an important stimulant to the increased use of yield-improving practices. Commercial fertilizers, for example, were the largest single factor in expansion of total crop production. In 1955, farmers used nearly $3\frac{1}{2}$ times as much commercial plant nutrients as in 1940. Fertilizer alone probably accounted for nearly half of the increase in crop outturn per acre and for more than a fifth of the addition to total farm output.

Greater use of improved varieties of crops contributed significantly to greater production. An outstanding example is hybrid corn, which usually raises yields per acre about 20 percent compared with the use of seed of open-pollinated varieties. Hybrid seed was planted on 73 million acres in 1955, or on nearly 90 percent of the total acreage planted to corn. The use of hybrid corn may have contributed 10 percent to the expanded crop outturn and 5 percent to the expanded farm output between 1940 and 1955.

Irrigation has been carried on in most of the western specialty-crop areas for a long time. Since 1940, irrigation has spread to the humid East. During the World War II and postwar period, additions to output from this source were four times as much per year as during the previous two decades.

Weather also influenced the change in crop production per acre and total farm output from 1940 to 1955. On the average, growing conditions were more favorable at the end than at the beginning of this period. But it is estimated that less than 10 percent of the increase in farm output was due to more favorable growing conditions. Climate varies widely among regions. Only on rare occasions, such as in the midthirties, do widespread droughts reduce farm output appreciably for the country as a whole.

The "mix" of intensive and extensive crops changed considerably during the 15 years following 1940. Acreage-allotment programs were in effect in 1955 on such crops as cotton, tobacco, corn, and wheat. A large part of the acreage taken out of these crops was put into feed grains, which ordinarily yield less per acre than allotment crops. The net effect of these shifts in acreages of crops produced was to lower the average United States crop production per acre.

Briefly then, the major source of increase in farm output from the Civil War to the end of World War I was an increase in the cropland base. Between World Wars I and II, the increase was due largely to the direct substitution of mechanical power for animal power. From World War II to 1955, the greater farm output resulted chiefly from technological improvement which increased production both per acre and per animal.

THE BACKGROUND

During the last nine decades, farm output in the United States has increased fourfold. This increase resulted from a combination of factors. The importance of any one factor and the combination of factors have varied over time.

What are some of these elements and how important have they been as sources of changes in farm output? In the study reported here, an attempt was made to measure the contribution to the increase in farm output of the shift from use of animal power to mechanical power on farms, the change in product added by livestock and in pasture consumed by livestock, the change in acreage of cropland used for crops,[1] and the change in crop production per acre. The relative importance of major subdivisions of elements that contribute to farm output can be estimated fairly directly from the data used in developing the index of farm output.

In addition, estimates have been made of the major factors that contribute to the change in crop production per acre.[2] They include increased use of fertilizer and hybrid seed corn, shifts in relative emphasis on intensive[3] and extensive crops, increased use of irrigation, major changes in weather, and so on. These factors are difficult to measure precisely because of the interrelationships among them. In an area in which water limits production, for example, it is difficult to allocate the part of the increased production that is due to irrigation and the part that is due to the use of a fertilizer.

Each of the nine census regions, as well as the United States as a whole, was studied. Each region has its own pattern of production, and factors responsible for the change in production vary among regions. The periods used for the study reported included the years from the post-Civil War period to 1955 for the United States, with primary emphasis on the periods since 1919-21. Regional analysis was for the period 1919-21 to 1955.

A study of the changing sources of farm output can be useful in several ways. In recent years, our farm plant has been more than able to meet our increasing domestic demand for farm products. If we are to meet our future increases in needs for farm products, the productive capacity of our farm plant must be increased. Moreover, the nature and direction of changing sources of farm output have important economic implications. The best facts possible are needed if we are to take intelligent action to adjust farm production to market demand in the years ahead. Knowledge of past sources of increase in our production is part of the needed facts. Analysis of past changes can help in appraising the impact that future demand may have on our farm plant. Consequently, a chief purpose of this analysis is to provide both a benchmark for looking ahead and a basis for economic analysis of production response.

Measuring Farm Output[4]

A general knowledge of the concepts and methods used in measuring the volume of output from our farm plant each year will be helpful in appraising the analyses presented in the rest of this report.

[1] Cropland used for crops includes harvested acreage plus acreages of crop failure and summer fallow.

[2] Here and elsewhere in this report, crop production per acre refers to the average aggregate production per acre of all crops. Yield per acre refers to individual crops.

[3] As the term is used in this report, intensive crops are those having higher than average value per acre. Extensive crops are those with lower than average value per acre.

[4] The historical series of farm output is published annually in Changes in Farm Production and Efficiency (6). (Numbers in parentheses refer to Literature Cited, page 51.)

Farm output measures the annual volume of farm production available for eventual human use through sales from farms or consumption in farm households.

Our farm production includes both crop and livestock production. Formerly, an important part of livestock production consisted of the farm-produced power of horses and mules. The components of farm production may be classified into (1) "producer goods" and (2) products for eventual human use. Producer goods are those used to further the production of products for eventual human use. Examples are feed grains and hay used to produce livestock and livestock products, farm-produced power supplied by horses and mules used to produce crops and do other farmwork, and seed produced for planting the succeeding year's crops. But all or a large part of most crop and livestock production is used to satisfy human wants, directly or indirectly.

To compute farm output for human use, producer goods must be eliminated and double counting of crop and livestock production avoided. Total crop and livestock production are added as a first step. From this total, production of certain grass seeds are subtracted. The hay and concentrates fed to all livestock are subtracted also. Volume of farm output and components of farm production are measured in constant dollars.[5] The data in table 1 show the components of farm production in 1947-49 and illustrate also the method by which components are combined to derive the measure of farm output.

In the process of calculating farm output, a measure of gross farm production was developed also. Gross farm production differs from farm output in that it includes farm production of two "producer goods," as shown in table 1--farm-produced power of horses and mules and production of certain grass and legume seeds. These producer goods have been important inputs in the process of farm production. Historically, farm-produced power has decreased from a fifth of gross farm production in 1910-14 to about 2 percent in the midfifties.

[5] Two weight periods were used. Average values per unit for 1935-39 were used as weights for 1910 to 1939. Weighted average value per unit for 1947-49 were used for the period beginning in 1940. The index series for the two subperiods were "spliced" together in 1940 through the use of overlapped calculations for that year. To construct farm output for years before 1910, Strauss and Bean's (4) index of production was spliced to the current index of farm output in 1910. For a more detailed explanation of the concepts and methods used in measuring the volume of farm output, see U. S. Dept. Agr. Handb. No. 118 (10).

In a sense, farm output measures the constant-dollar value of the end products of our farm plant. In another sense, gross farm production is a measure of the total contribution of all land, labor, and other inputs used in farm production.

In general, farming throughout the United States assumed its present form in response to well-defined physical, biological, and economic forces or conditions. Because of the diversity of our agriculture, measures of farm output have been developed for each of the nine census regions as well as for the United States as a whole. These regions were used to present regional aspects of farm production, chiefly because most of the necessary basic data had been previously summarized by these breakdowns. The farm-output measures developed by regions and divided into various components made useful tools of analysis for the study reported. They enabled the authors to determine what commodities and which regions have contributed most to changes in aggregate farm output.

Geographical and Commodity Distribution of Farm Output

The commodities that make up farm output vary greatly among regions. In analyzing recent trends in output, these differences need to be considered. Therefore, the first step in the analysis is to present a generalized picture for a recent period of the regional distribution and commodity composition of farm output. The period used in this section is the average of 1947-49.

The average crop production in 1947-49 for the United States as a whole was valued at nearly $20 million (table 2). More than a fourth of it came from the west north-central region. The combined crop production of the north-central division accounted for more than 40 percent of the total for the United States, while the northeastern, the southern, and the western divisions accounted for 6, 34, and 17 percent, respectively.

The relative importance of an individual crop within a region depends partly on the distance from market and the climate. In regions close to population centers, production of such intensive crops as vegetables and fruit tends to be important. These two groups of crops accounted for more than half of the total crop production in the New England and Pacific regions in 1947-49, and for about 40 percent in the

TABLE 1.--Basic production aggregates used in computing components of gross farm production and farm output, United States, average 1947-49

Item	Basic production aggregates	Components of gross farm production	Components of farm output
	Million dollars	*Million dollars*	*Million dollars*
Crop production:			
Seeds[1]	143.7	143.7	--
All other	19,595.2	19,595.2	19,595.2
Total	19,738.9	19,738.9	19,595.2
Livestock production:[2]			
Feed other than pasture	8,411.0	--	--
Pasture consumed	1,597.5	1,597.5	1,597.5
Product added	6,510.6	6,510.6	6,510.6
Total	16,519.1	8,108.1	8,108.1
Farm-produced power:[3]			
Feed other than pasture	827.3	--	[4] -827.3
Pasture consumed	202.3	202.3	--
Product added	393.5	393.5	--
Total	1,423.1	595.8	-827.3
Total of components	--	28,442.8	26,876.0

[1] Includes only hay seeds, pasture seeds, and cover-crop seeds.

[2] All livestock and livestock products except for farm-produced power of horses and mules.

[3] Farm horses and mules.

[4] Farm-produced power not a part of farm output. Subtracted to avoid double counting of part of "total crop production."

middle Atlantic region. In none of the remaining six regions did combined production of vegetables and fruits make up more than 25 percent of the total crop production.

Extensive crops, such as food and feed grains, are produced in regions distant from market. In 1947-49, the combined production of food and feed grains in the east north-central, west north-central, and mountain regions was 65, 75, and 42 percent, respectively, of total crop production. Except in New England, where food and feed grains accounted for only 5 percent, these grains contributed from a fifth to a third of the total production of crops in each of the remaining regions.

Cotton and tobacco were the chief crops produced in the southern division. Combined production of these two crops was responsible for more than 40 percent of the total production of crops in the south Atlantic region, and 50 percent in the east south-central region and 45 percent in the west south-central region.

The value of gross production of livestock and livestock products in the United States in 1947-49 averaged more than $16 million annually (table 3). More than half was produced in the north-central division. The southern division produced close to one-fourth of the total, while the northeastern division produced 11 percent and the western 12 percent.

Production of meat animals accounted for close to half of the gross livestock production in the United States. Meat animals were the main livestock group in the east north-central, west north-central, east south-central, west south-central, and mountain regions. In these regions, they accounted for about half of the total production of livestock.

TABLE 2.--Value of crop production, by crop groups, United States and census regions, average 1947-49[1]

Commodity[2]	United States	New England	Middle Atlantic	East north central	West north central	South Atlantic	East south central	West south central	Mountain	Pacific
	Million dollars	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*
Feed grains	6,157	19	207	1,929	2,587	411	406	331	151	116
Hay and forage	2,277	108	214	430	549	164	159	175	255	223
Food grains	2,814	([3])	75	350	1,154	64	23	521	375	252
Vegetables	2,514	166	273	301	191	419	160	225	249	530
Fruits and nuts	1,059	27	69	84	16	202	26	55	27	553
Sugar crops	224	4	3	15	19	15	9	45	67	47
Cotton	2,515	--	--	([3])	73	347	618	1,193	105	179
Tobacco	925	43	16	24	3	589	250	([3])	--	--
Oil crops	1,038	--	2	331	366	180	58	69	10	22
Seed crops	144	--	1	23	43	12	11	9	21	24
Miscellaneous crops	72	--	--	12	3	5	3	11	5	33
All crops	19,739	367	860	3,499	5,004	2,408	1,723	2,634	1,265	1,979

[1] Here and elsewhere in this report, the regions used and the States in each region are as follows: New England - Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut; Middle Atlantic - New York, Pennsylvania, New Jersey; East north central - Ohio, Indiana, Illinois, Michigan, Wisconsin; West north central - Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas; South Atlantic - Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, West Virginia; East south central - Kentucky, Tennessee, Alabama, Mississippi; West south central - Arkansas, Louisiana, Oklahoma, Texas; Mountain - Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada; Pacific - Washington, Oregon, California.

[2] Here and elsewhere in this report, the crop groups and the crops in each are as follows: Feed grains - all corn, oats, barley, and sorghum grain; hay and forage - all hay, sorghum forage, and sorghum silage; food grains - all wheat, rye, buckwheat, and rice; vegetables - potatoes, sweetpotatoes, dry edible beans, dry field peas, truck crops for fresh market, truck crops for processing, and farm gardens; fruits and nuts - fruits, berries, and tree nuts; sugar crops - sugar beets, sugarcane for sugar and seed, sugarcane sirup, sorghum sirup, maple sugar, and maple sirup; cotton - cotton lint and cottonseed; tobacco; oil crops - soybeans, peanuts picked and threshed, peanuts hogged, flaxseed, and tungnuts; seed crops - hay seeds, pasture seeds, and cover-crop seeds; miscellaneous - cowpeas, hops, broomcorn, popcorn, peppermint, and spearmint.

[3] Less than $0.5 million.

TABLE 3.--Value of all livestock production, by livestock groups, United States and census regions, average 1947-49[1]

Region[2]	All livestock and livestock products[3]	Meat animals	Dairy products	Poultry products	Miscellaneous livestock
	Million dollars	*Million dollars*	*Million dollars*	*Million dollars*	*Million dollars*
New England	485	43	230	211	1
Middle Atlantic	1,390	222	712	450	6
East north central	3,801	1,864	1,295	625	17
West north central	4,896	3,282	832	758	24
South Atlantic	1,368	453	419	487	9
East south central	1,033	496	328	203	6
West south central	1,519	828	361	291	39
Mountain	949	633	166	107	43
Pacific	1,079	342	410	312	15
United States	16,520	8,163	4,753	3,444	160

[1] Composed of three major parts, product added, pasture, and feed other than pasture. The latter is deducted when livestock and crops are combined for the purpose of computing farm output.

[2] For regional groupings of States, see table 2, footnote 1.

[3] In this table and elsewhere in this report, the livestock groups and livestock products in each are as follows: Meat animals - cattle and calves, hogs, and sheep and lambs; dairy products - butter, butterfat, wholesale milk, retail milk, and milk consumed on farms; poultry products - chicken eggs, commercial broilers, chickens, and turkeys; and miscellaneous - clipped wool, mohair, honey, and beeswax.

Nearly 30 percent of the 1947-49 value of livestock production in the United States was made up of dairy products. Their importance within census regions is related to nearness to market. Dairy products were the chief item of livestock production in the middle Atlantic and Pacific regions. In New England also, they were most important but were followed closely by poultry and eggs. The north-central division produced nearly half of all dairy products in the United States, with the east north-central region accounting for more than a fourth of the total.

Production of poultry and eggs in the United States is fairly evenly distributed among regions. In no region was it the chief kind of livestock production. But as with the two previous livestock groups, the north-central division produced the largest share of the total U. S. production of poultry products.

Because the north-central division leads in the production of both crops and livestock, it also leads in contribution to total farm output. As shown in table 4, in 1947-49, this division accounted for $12 billion of the U. S. total output of $27 billion. The southern division contributed $8 billion; the western, $4 billion; and the north-eastern, $2 billion.

The crop component was by far the major part of farm output in all regions and in the United States as a whole. It ranged from 55 to 80 percent in the regions and averaged 70 percent for the United States. (The crop component of farm output equals total crop production minus hay and pasture seed crops, and hay and concentrates fed to horses and mules.)

Gross farm production credits agriculture with the production of two "producer goods"--farm-produced power and grass seeds. Therefore, gross farm production equals farm output plus farm-produced power and grass seed. The differences between gross farm production and farm output vary among regions primarily in the degree to which farmers produce their own power on farms via horses and mules. The

TABLE 4.--Value of farm output and its major components, United States and census regions, average 1947-49

Region[1]	Farm output	Livestock component[2]	Crop component[3]
	Million dollars	*Million dollars*	*Million dollars*
New England	570	221	349
Middle Atlantic	1,484	671	813
East north central	5,201	1,825	3,376
West north central	7,116	2,308	4,808
South Atlantic	2,815	587	2,228
East south central	2,031	486	1,545
West south central	3,398	883	2,515
Mountain	1,755	555	1,200
Pacific	2,506	572	1,934
United States	26,876	8,108	18,768

[1] For regional groupings of States, see table 2, footnote 1.
[2] Includes product added and pasture consumed by livestock other than horses and mules.
[3] Total crop production minus production of grass seeds and hay and concentrates fed to horses and mules.

TABLE 5.--Value of farm output, farm-produced power, and gross farm production, United States and census regions, average 1947-49

Region[1]	Farm output[2]	Farm-produced power[3]	Gross farm production[4]
	Million dollars	*Million dollars*	*Million dollars*
New England	570	28	598
Middle Atlantic	1,484	76	1,561
East north central	5,201	158	5,381
West north central	7,116	278	7,437
South Atlantic	2,815	268	3,095
East south central	2,031	270	2,313
West south central	3,398	209	3,615
Mountain	1,755	92	1,869
Pacific	2,506	44	2,574
United States	26,876	1,423	28,443

[1] For regional grouping of States, see table 2, footnote 1.
[2] Agricultural production available for human use.
[3] From horses and mules.
[4] Farm output plus farm-produced power and production of grass seeds.

shift in relationship between gross farm production and farm output over time among regions varies according to the rate of substitution of mechanical for animal power. The average 1947-49 U. S. gross farm production was 6 percent larger than farm output; 5 of the 6 percentage points were accounted for by farm-produced power (table 5). Gross farm production in 1947-49 was 3 to 6 percent larger than farm output

in all regions, except the south Atlantic and east south-central region, where it was 10 and 14 percent larger, respectively.

The measure of farm output was used here instead of gross farm production as the analysis is concerned chiefly with the changes in agricultural production for eventual human use.

LONG-TERM TREND IN FARM OUTPUT

Except for interruptions during the drought period of the 1930's, the long-term trend in volume of farm output in the United States has been consistently upward since 1870. In 1955, farm output was nearly five times as large as it was 85 years previously (table 6). The annual rate of increase in output has been influenced by wars, Government programs at home and abroad, industrialization, changes in technology, weather, and economic conditions.

Demand for agricultural products has increased greatly, as indicated by the changes in population of the United States and the volume of agricultural exports (fig. 1). In 1955, population was more than four times that of 1870. Agricultural exports have fluctuated greatly throughout the 85 years, but in 1955, they were four times as great as in 1870. From 1870 to 1880, about three-fourths of the value of all exports from the United States consisted of agricultural products. But as our Nation became more industrialized, the proportion decreased. By 1955, less than a fourth of total exports was made up of agricultural products.

On a percentage basis, farm output increased a third more than the acreage of cropland from 1870 to 1955 (fig. 2). Improved technology in the form of fertilizer, herbicides, insecticides, improved plant varieties, and mechanical power resulting in more timely operations, was dominant in an increase in farm output per acre of more than 50 percent during the period. Increased use of mechanical power reduced the need for horses and mules on farms by about half. The reduction in the number of horses and mules released millions of acres of cropland and vast quantities of other resources to production for human use.

For purposes of analysis in this report, the longer term history of our increase in farm output since 1870 can be divided into four significant periods: (1) Post-Civil War to the turn of the century, 1870-1900; (2) Pre-World War I and War period, 1900-1920; (3) Interwar period, 1920-40; and (4) World War II and postwar period, 1940-55.

Post-Civil War to Turn of the Century, 1870-1900

During this period, agricultural development was stimulated by the homestead policy, mechanical improvements, and advances in transportation. The rapid rise in output resulted largely from the increase in acreages of farmland and cropland used for crops. The acreage of farmland was more than doubled, and that of cropland used for crops was increased by more than 150 percent. Improvement of roads, railroads, and canals made it possible to market farm products from areas distant from markets. Soon after the turn of the century, through Government help and encouragement, the total mileage of railroads in the United States exceeded the mileage in all Europe.

In terms of one measure, production per farmworker increased 50 percent during the 30 years. It has been estimated that in 1870, one farmworker produced enough to support himself and four other persons. By 1900 he produced enough to support himself and six other persons. Much of the new horse-drawn machinery that had been developed before the Civil War was adopted more widely. The additional use of machinery required the use of more horse and mule power. As a result, there was a general displacement of man labor by animal power and machines. Farm-produced power of horses and mules increased at about the same rate as farm output.

This period was one of rapid expansion of agricultural production, which was stimulated by rapid industrialization at home and abroad. The proportion of the total labor force in agriculture declined from 53 to less than 40 percent. Chiefly as a result of the creation of a Federal Department of Agriculture, the passage of the Morrill Act in 1862, which started the land-grant colleges, and the Hatch Act in 1887, which inaugurated the State Experiment Stations, agricultural research developed on a scientific basis.

Farm output increased 143 percent, or at an annual rate of 3 percent during the period. Farmers started the shift from a

TABLE 6.--Change in farm output and related factors, United States, specified periods, 1870-1955[1]

Item	1870-1900		1900-1920		1920-40		1940-55		1870-1955	
	Percentage change	Annual rate of change	Percentage change	Annual rate of change	Percentage change	Annual rate of change	Percentage change	Annual rate of change	Percentage change	Annual rate of change
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Farm output.....	143	3.0	19	0.9	26	1.2	34	2.0	385	1.9
Agricultural exports[2]...	296	4.7	11	.5	-60	-4.4	135	5.9	319	1.7
Population.....	91	2.2	40	1.7	24	1.1	25	1.5	314	1.7
Cropland used for crops.	153	3.1	22	1.0	-1	-.1	3	.2	213	1.4
Farm-produced power.....	136	2.9	22	1.0	-45	-2.9	-74	-2.1	-59	-2.5

[1] 3-year averages centered on years shown.
[2] For source of data see U. S. Dept. Agr. Statis. Bul. 112 (8).

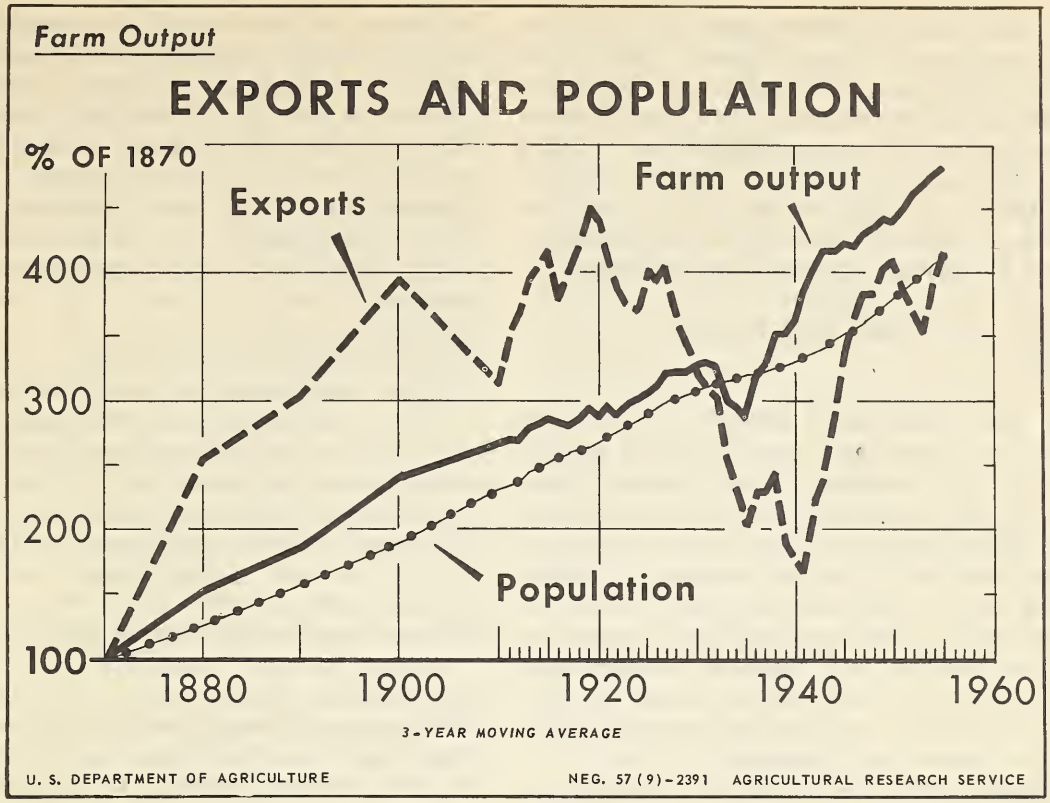

Figure 1.--Farm output has increased at a faster annual rate than population. Agricultural exports have fluctuated widely.

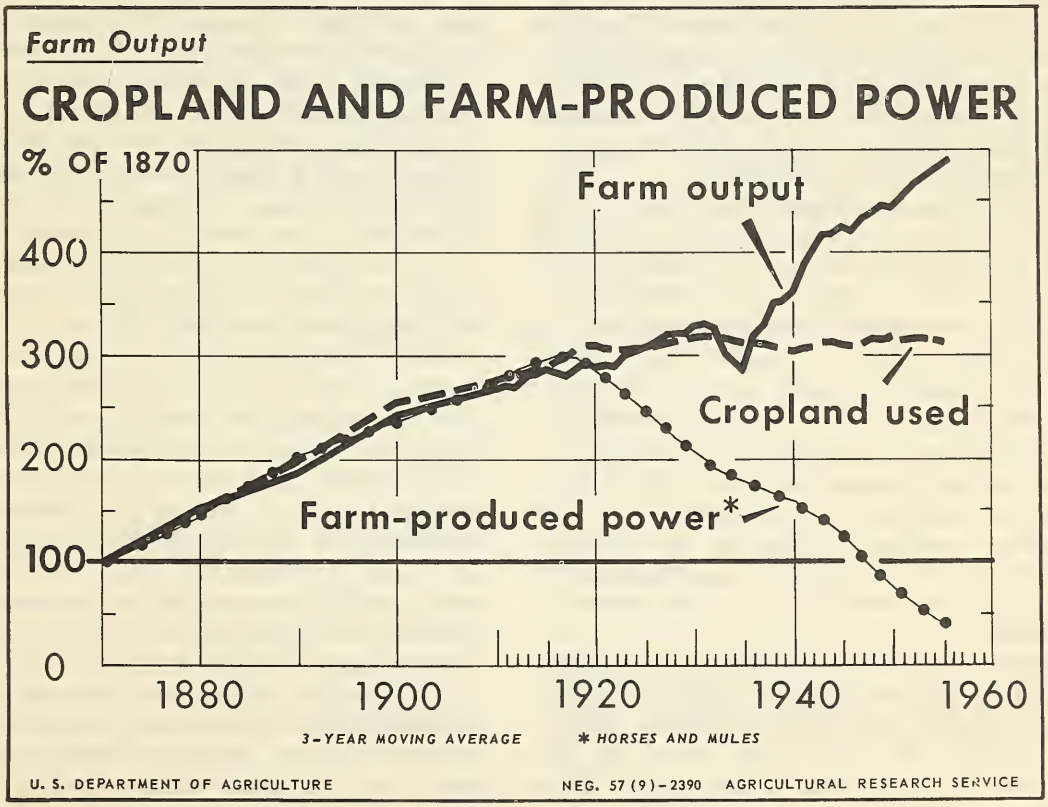

Figure 2.--The acreage of cropland and the volume of farm-produced power increased at the same rate as farm output from 1870 to about 1920. Since 1920 farm-produced power has decreased rapidly, while the acreage of cropland has remained fairly constant.

more or less subsistence type of farming to more commercialized types. Domestic demand for farm products rose because of a 90-percent increase in total population and a sharp increase in exports. By 1900 exports of farm products were almost three times as large as in 1870, and the value of agricultural exports was 25 percent of the realized gross farm income.

Pre-World War I and War Period, 1900-1920

As in the previous period, continued expansion of cropland area was a major factor in the increase in farm output from 1900 to 1920. Cropland used for crops rose by 22 percent, with most of the increase coming on existing farms. Much of the added acreage was in the area of limited rainfall. Farm-produced power of horses and mules on farms reached its peak in 1918. By the latter part of this period mechanical power was being substituted for horses and mules.

Farm output increased by 19 percent but at a much slower annual rate than in the previous period. The wartime program of stimulus to production depressed production of some semiluxury foods because of the imperative need for bread, meats, fats, sugar, and wool. Owing to a combination of favorable growing conditions and attractive prices occasioned by increased demand, the only billion-bushel crop of wheat produced before 1944 came in 1915.

The period was a prosperous one. During the first 14 years, agricultural production was fairly well balanced with demand. Then came World War I, when the agricultural policy of the Federal Government was to stimulate production to meet the added demands for food for our allies. Further impetus was given to improvement in farming methods by the passage in 1914 of the Smith-Lever Extension Act, which provided for a nationwide extension of the county agent system, and the passage in 1917 of the Smith-Hughes Act, which provided agricultural education in our secondary schools.

During the period, population increased by 40 percent. As a result, domestic demand rose. The volume of farm exports was 11 percent larger at the end than at the beginning of the period. During the first half of the period, however, the volume of exports decreased by almost a fourth. But as domestic demand increased, farmers were able to adjust to the situation. The volume of farm exports stepped up before World War I started, and the stimulus of wartime foreign demand raised our exports to an all-time high. Because exports of agricultural products did not increase as rapidly as did farm output and because prices received for agricultural products decreased, only 16 percent of the gross farm income came from agricultural exports in 1920.

Interwar period, 1920-40

The interwar period witnessed the end of the expansion in acreage of cropland and the onset of mechanization as a dominant factor in the growth of farm output.

This 20-year period was one of contrasting world conditions. The first half was relatively prosperous, but in the United States the second half was characterized by economic depression and major droughts.

Farm output continued its upward trend throughout the period, except for interruptions during the droughts of the 1930's. Because of the wide variation in climate in the United States, the droughts of 1934 and 1936, which were national in scope and which greatly reduced total farm outturn, were exceptions.

Farm output increased 25 percent over the period. The average increase per year was greater than in the previous period.

From 1920 to 1930, the population of the United States rose at about the same rate as in the previous period. With the onset of economic depression, the rate of growth slowed down. During the two decades, however, the overall increase was 24 percent, slightly less than the percentage rise in farm output. Exports decreased sharply during this period. Their value declined from 16 percent of the realized gross farm income in 1920 to 3 percent in 1940. During the prosperous world conditions of the 1920's, exports remained at a relatively high level. But the world depression of the early thirties brought a sharp decline in volume of agricultural exports. Droughts in the United States, plus programs of self-sufficiency in farm production in other countries, dropped our farm exports to the lowest level since around 1875.

Expansion of the total acreage of cropland halted early in the period, and technological improvement became increasingly important as a means of expanding farm output. The area of cropland used for crops remained fairly constant for the United States as a whole, but farm output per acre increased by 25 percent.

The shift from farm-produced power of horses and mules to tractor power was the chief factor in the stepped-up outturn of farm products. In the midtwenties, the first successful row-crop tractor was developed; as the number of tractors increased, the number of horses and mules decreased. Farm-produced power of horses and mules declined by 45 percent. The acreage of cropland used to raise feed for horses and mules decreased by more than 45 million acres in the 20 years. The reduction in this acreage was a major factor in the increase in farm output for human use.

Development of hybrid corn increased yields of corn by 20 percent above those obtained from open-pollinated varieties. By 1940, 30 percent of the acreage of corn was planted to hybrid seed.

World War II and Postwar Period, 1940-55

Following 1940, our farm production was stimulated by the increased demands occasioned by World War II, Government programs for foreign relief, the step-up in demand during the Korean conflict, and, in general, by increased purchasing power at home and abroad. Farm output rose as much from 1940 to 1955 as it had increased in the previous 40 years. Half of this increase came in the early forties. Because of the emergency needs for farm products, the backlog of technological developments, and the favorable price-cost relationships, output increased at a greater rate than it would have done under usual peacetime conditions.

The increase in farm output in this period resulted chiefly from greater use of new technology. Much of the research foundation was laid in the interwar period. But market inducements for larger production were not great in the earlier period. The acreage of cropland used for crops changed little during the period, but an additional 35 million acres were made available for production for human use as the number of horses and mules decreased rapidly. By 1955, the volume of farm-produced power was only half that of 1870 and only about a sixth of that of the 1917-18 peak. The shift from animal to mechanical power was practically completed by 1955.

The rate of increase in population for the period was a third greater than during the two decades from 1920 to 1940. After World War II, population rose at the highest rate since 1900. During the early forties, farm output increased much faster than population, but since 1945, both have increased at about the same rate.

Foreign demand for our agricultural products improved rapidly after its near collapse in 1940-41. The lend-lease programs of World War II started the volume of exports upward. Emergency relief programs following World War II increased exports to a postwar high. From 1949 to 1955, exports declined slightly. Government export programs accounted for a third of the average 1950-55 volume of agricultural exports. But despite increased demands at home and abroad, farm output expanded more rapidly, thus creating a major adjustment problem in the midfifties.

SOURCES OF FARM OUTPUT FOR THE UNITED STATES

The highlights concerning major trends in farm output of the United States and the regional distribution and commodity composition of farm output were presented in previous sections. The rest of the discussion is intended chiefly to analyze the changes in farm output and, in particular, to approximate the relative importance of the major sources of increase in farm output. Three periods are examined in detail. They are the interwar period, 1919-21 to 1938-40; the World War II and immediate postwar period, 1940-41 to 1951-52; and a more recent period, 1951-52 to 1955.[6]

These periods have distinctive characteristics. The interwar period was marked by the shift from animal to mechanical power as a major source of increase in

[6] To construct the index of farm output, average 1935-39 prices were used as price weights for the years previous to 1940. For 1940 to date, 1947-49 prices were used. The index series were spliced together at 1940. Owing to the use of these two sets of price weights, the ending years of the interwar period and the beginning years of the World War II periods are not identical.

farm output. In the World War II and immediate postwar period, expanding demand for agricultural products was met by increased use of new technology and continued shift to mechanical power. The more recent period is marked chiefly by increased use of technological innovations as the shift to mechanical power neared completion.

Farm output for the United States increased more on a percentage basis during the 11 years of the World War II and immediate postwar period than during the previous 19 years (table 7). From 1951-52 to 1955, farm output was stepped up by 7 percent. This increase is more noteworthy when viewed in terms of the annual rate of increase. During the interwar period, farm output increased at an annual rate of 1.1 percent. This rate was almost doubled in the two periods under consideration since 1940.

As farm output is computed by separate components, these components provide data that can be used in analyzing the factors associated with longer term changes in total outturn of crop and livestock products. For example, on the basis of results of the output calculations, changes in total farm output can be divided into five major sources of change. These sources are as follows: (1) The shift from farm-produced animal power to mechanical power; (2) the change in the number of acres of cropland used for crops; (3) the change in crop production per acre; (4) the change in the amount of product added in production of livestock; and (5) the change in pasture consumed by all livestock.

The relative importance of these individual sources of farm output has changed over time (fig. 3). The proportion of the increased farm output coming from the shift from animal to mechanical power has tended to decrease over time. But crop production per acre and product added by livestock have tended to become more important as sources of the stepped-up farm outturn. The contribution of cropland and pasture to feed consumed by livestock has shown no definite trend. In the next several sections of this report, each of these major sources of change in farm output for the United States is analyzed in detail.

The Shift From Use of Farm-Produced Power to Mechanical Power

The reduction of farm-produced power has been an important source of our increase in farm output. As farm horses and mules were replaced by tractors and other power units, great amounts of land, labor, and other production resources were released from production of animal power on farms to output of livestock and crops for more direct human use.

The data in table 8, in which production is expressed in 1947-49 dollars, illustrate the method used in estimating the contribution of the reduction in farm-produced power to the change in total farm output. The total value of crop production increased by $3,000 million from 1940-41 to 1951-52. At the same time, the value of hay and concentrates fed to horses and mules decreased by $790 million. Thus hay and concentrates no longer needed to feed horses and mules were available for other livestock production or for more direct human use. Consequently, total value of crop production available for eventual human use increased by $3,790 million during the period ($3,000 and $790). Similarly, the reduction in farm-produced power brought about a transfer of pasture,

TABLE 7.--Changes in value of farm output, United States, specified periods, 1919-55

Period	Change in value	Percentage change	Annual rate of change
	Million dollars	*Percent*	*Percent*
1919-21 to 1938-40	[1] 1,554	22	1.1
1940-41 to 1951-52	[2] 5,607	25	2.0
1951-52 to 1955	[2] 1,973	7	2.0

[1] Measured in 1935-39 dollars.
[2] Measured in 1947-49 dollars.

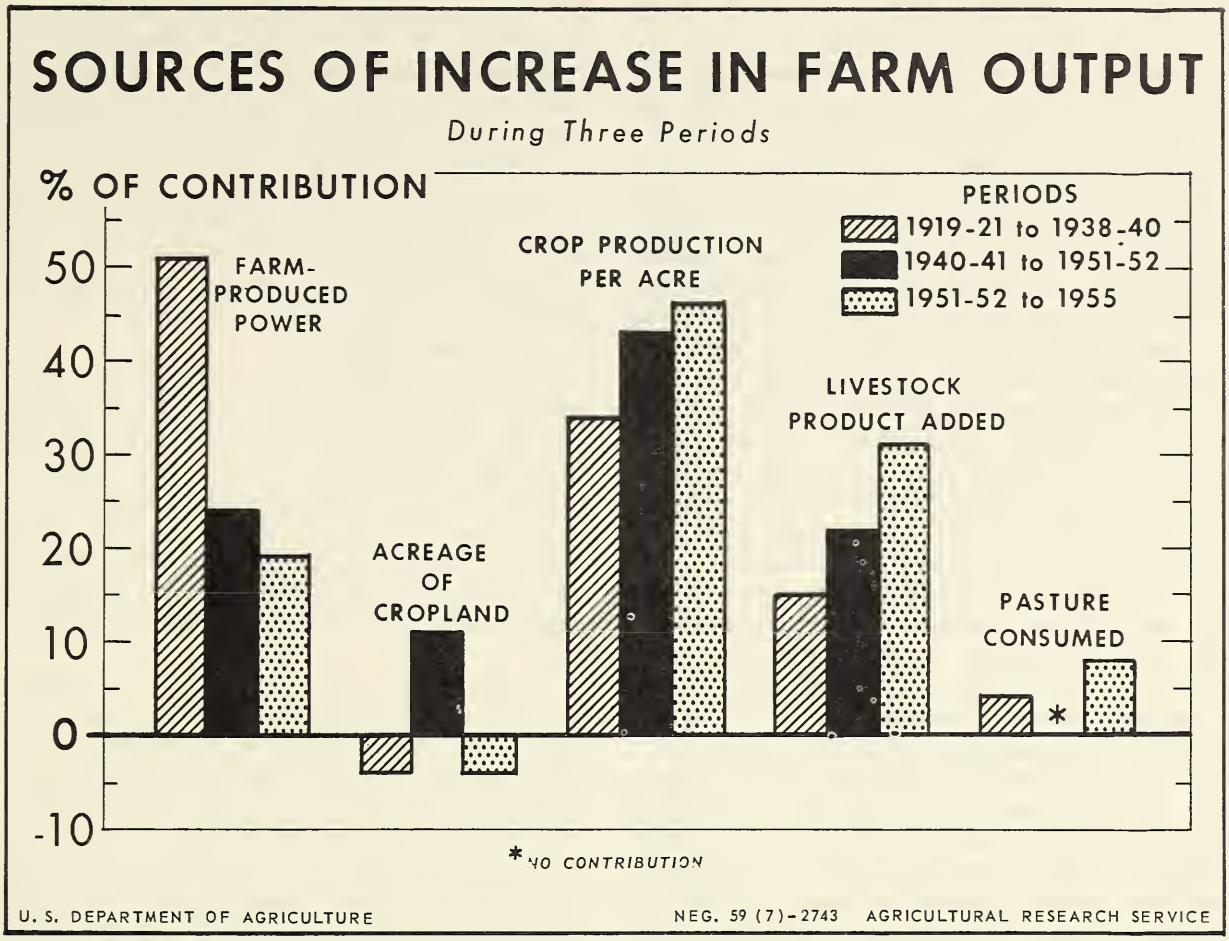

Figure 3.--The relative importance of the reduction in farm-produced power decreased from 1919 to 1955, while changes in crop production per acre and product added by livestock increased.

TABLE 8.--Transfer of farm-produced power to commodities for human use, United States, 1940-41 to 1951-52[1]

Item	Average		Change 1940-41 to 1951-52
	1940-41	1951-52	
	Million dollars	*Million dollars*	*Million dollars*
Crop production[2]	16,775	19,776	3,001
Less hay and concentrates used by farm-produced power	1,360	571	-789
Crop production available for human use	15,415	19,205	3,790
Product added by all livestock[3]	8,171	9,418	1,247
Less product added by farm-produced power	981	411	-570
Product-added available for human use	7,190	9,007	1,817
Total farm output	22,605	28,212	5,607

[1] Measured in 1947-49 dollars.
[2] Excludes production of grass and legume seeds.
[3] Product-added includes pasture.

labor, and other resources equivalent to $570 million of output for human use.

The reduction in farm-produced power was the chief source of the increased farm output during the interwar period (table 9). Farm output increased by 0.77 index points per year, of which 0.39 index points were due to the reduction in farm-produced power. The number of horses and mules decreased by 11 million head, while the number of tractors increased by 1,321,000 units. Just after World War I, about 80 million acres were used to produce the hay and grain consumed by horses and mules--more than a fifth of the total crop acreage harvested. By 1938-40, only 44 million acres, or an eighth of the total crop acreages harvested, were required to produce the feed necessary for horses and mules.

The transfer of production resources used in developing animal power to production of livestock and crops for human use was the second main source of increased farm output from 1940-41 to 1951-52. It accounted for a fourth of the increase.

In terms of absolute volume, this transfer of resources contributed a larger amount per year during World War II and immediate postwar years than in the interwar years, even though it was second in importance as a source of output. The number of horses and mules continued the downward trend started in the previous period, decreasing 50 percent, while the numbers of tractors more than doubled. By 1951-52, only 4 percent of the crop acreage harvested was needed to raise the feed necessary for horses and mules on farms.

From 1951-52 to 1955, the reduction of farm-produced power decreased in relative importance as a source of added farm output. It ranked third as a source and accounted for about a fifth of the increased farm output. Farm output increased by 2 index points per year, of which 0.38 point was due to the reduction of farm-produced power. The per-year contribution was about the same as it was during the interwar period. By 1955, the number of horses and mules had decreased to 4 million head, and the number of tractors on farms had increased to more than 4 million units. In that year, fewer than 10 million acres of cropland were required to raise the necessary feed for horses and mules.

Product Added by all Livestock

Product added by livestock represents the value added as a result of conversion of concentrate feeds, hay, and pasture into livestock and livestock products. Thus, product-added may be considered as the return to factors of production other than feed and pasture, for labor, capital for livestock, buildings, and so on.

The primary way in which total product-added can be increased is through expansion of production of "feed-base" crops. Production of feed grains, hay, and pasture has been increased by adding acres and by increasing yields.

Another means of increasing product-added has been improvement of feed conversion by livestock. Past changes in feeding efficiency have been neither very large nor very consistent, except for broilers. During the two decades since the midthirties, the amount of feed required to raise a pound of broiler meat, for example, decreased by about 2 pounds (6, 1957, table 11).

As noted previously, gross livestock production can be divided into three parts--hay and concentrates consumed, pasture consumed, and product added in converting feed into livestock and livestock products.[7] It is necessary to break total livestock production into these separate components to avoid double counting of hay and concentrates fed to livestock when combining production of crops and production of livestock into total farm output.

The annual rate of increase in product-added by all livestock has turned sharply upward. During the interwar period, it contributed 0.12 index point of the stepped-up farm output per year. This rate was stepped up to 0.41 index point annually from 1940 to the Korean outbreak and to 0.62 index point annually during the recent period. Part of this change can be attributed to the increased production per animal breeding unit of productive livestock (fig. 4). The net result of the increased annual rate of change has been to make product-added an increasingly more important source of increase in farm output for the United States as a whole.

Product-added ranked third in importance as a source of increased farm output during the interwar period, when it ac-

[7] Feed used by livestock was calculated as a constant proportion of gross livestock production. These feed factors, which were derived after studying farm-management reports and unpublished estimates of feed consumption of different classes of livestock, were used each year for all classes of livestock except horses and mules. As the overall feeding efficiency has changed so little, it is believed that this is not a serious limitation to the analysis.

TABLE 9.--Annual changes in index points of farm output, by source of change, United States, specified periods, 1919-55[1]

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power	0.39	51	0.45	24	0.38	19	0.44	23
Change in product added by all livestock	.12	15	.41	22	.62	31	.47	25
Change in pasture consumed by all livestock	.03	4	0	0	.16	8	.04	2
Change in cropland used	-.03	-4	.20	11	-.08	-4	.13	7
Change in crop production per acre	.26	34	.80	43	.92	46	.82	43
Total change in farm output	.77	100	1.86	100	2.00	100	1.90	100

[1] Changes are measured in farm output index points, with the average of the years 1947-49 taken as a base of 100 points. This provides a measure of absolute change, and makes possible comparisons of the relative importance of sources of change within a period as well as between periods. For example, during the interwar period, the annual increase in farm output averaged 0.77 percent of the average 1947-49 volume of farm output in the United States; from 1940-41 to 1955, it averaged 1.90 percent annually.

counted for about one-seventh of the increase (table 9). This increase was associated partly with a larger production per breeding unit of productive livestock and partly with changes in composition of livestock. Animal units of breeding livestock decreased nearly 3 percent, while average production per unit--milk per cow, eggs per layer, and so on--rose by a third. Improved breeds, better-balanced rations, improved insecticides, and improved management were some of the factors responsible for this increase.

During the World War II and immediate postwar period, product-added continued to rank third as a source of the increased output but contributed more than a fifth of the increase. The larger livestock production was due to the combination of an 8-percent increase in the number of breeding units and a 15-percent rise in production per unit. In 1951-52, there were 2.5 million fewer milk cows on farms than in 1940-41, but average production per cow was increased about 700 pounds, or 14 percent, during the period. Consequently, total production of milk rose from 112 to 115 billion pounds. During the same period, the average number of hens and pullets on farms during the year increased by 25 million. Annual production per layer, which was stepped up by 43 eggs, or more than 30 percent, resulted in an additional 17 million eggs.

The relative importance of product-added as a source of farm output increased during the recent period, when it moved to second place and accounted for about a third of the added farm output. In terms of farm output index points, product-added annually contributed five times the amount it contributed during the interwar period. As in the two previous periods, production per unit of livestock continued to increase. The absolute increase in production of milk per cow and eggs per layer during the $3\frac{1}{2}$-year period was as great as that during the much longer interwar period.

Pasture Consumed by all Livestock[8]

In the past, pasture was not an important source of our increased farm output. The much greater increase in product-added by livestock than in pasture consumed was due partly to changes in composition or mix of livestock production. Poultry production, which calls for little or no pasture, has become a larger proportion of total livestock production. Also, as the number of horses and mules decreased, pasture was released for use by other livestock.

The total acreage of open pasture and grazing lands in the United States has changed little since 1920. But improved pasture and grazing management have increased the carrying capacity of an acre of pasture. Indications are that the amount of fertilizer used on pasture has trended upward.

Pasture contributed nothing to the increase in farm output during the World War II and immediate postwar period (table 9). As pasture consumed by horses and mules decreased during this period, pasture consumed by other livestock increased enough to maintain total pasture consumption at the same level. But during the interwar and recent periods, consumption of pasture by livestock other than horses and mules increased faster than did reduction of farm-produced power. Thus, increased consumption of pasture by all livestock accounted for 4 percent of the stepped-up farm output during the interwar period and for 8 percent during the recent period.

Changes in Cropland

The total acreage of cropland used for crops for the United States as a whole has changed little since 1919 (fig. 4). The slight year-to-year variations that did occur were due chiefly to variations in weather and in economic conditions. During the interwar period, cropland used for crops decreased about 1 percent. The effect was to hold down the increase in farm output.

From 1940 to 1955, there were divergent movements in the number of acres of cropland used. A 4-percent increase in acreage occurring from 1940-41 to 1951-52 was responsible for about 10 percent of the stepped-up outturn of farm products, but from 1951-52 to 1955, the acreage of cropland declined slightly. The net effect of changes in cropland for these periods combined was an increase in farm output of about 5 percent.

Substantial changes in the acreage of cropland took place in the major geographic divisions. In general, the northeastern and the southern divisions recorded decreases during the $3\frac{1}{2}$ decades from 1920

[8] The pasture component of gross livestock production was calculated as a constant proportion of total feed consumed by different classes of livestock. The same factors were used each year for all classes of livestock except for horses and mules. This measure provides a means of approximating changes in the total quantity of pasture consumed by livestock.

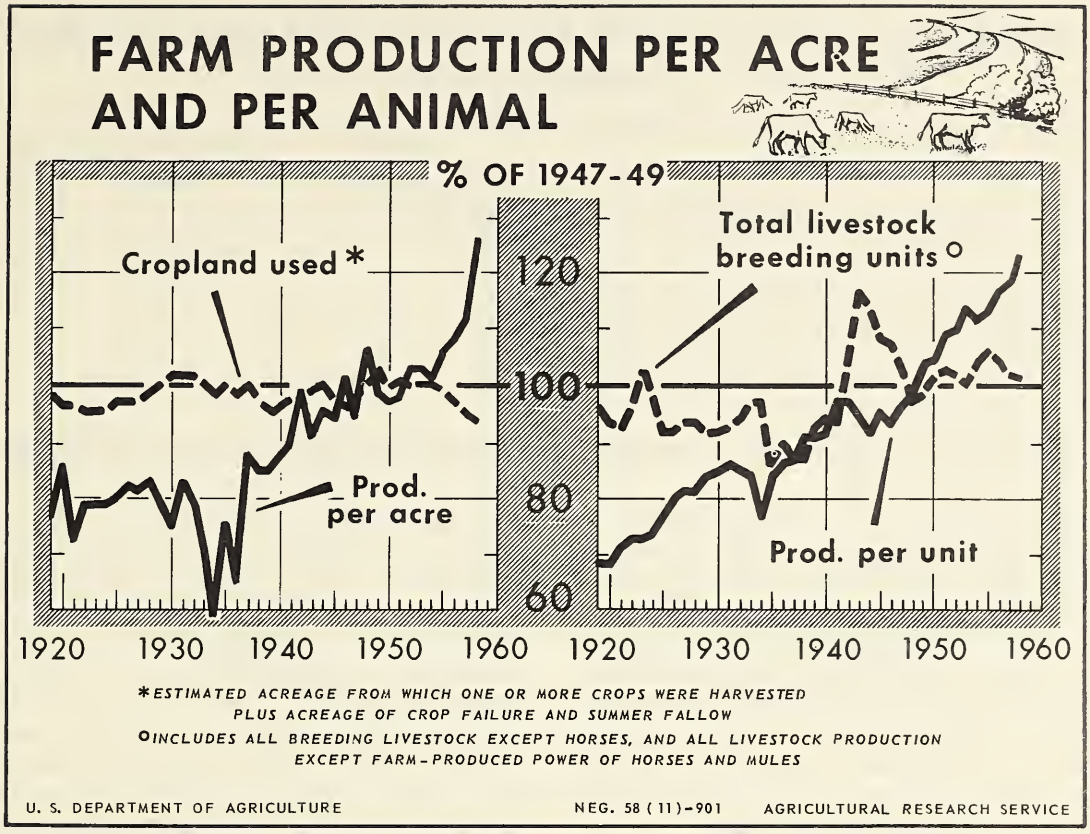

Figure 4.--Production per livestock breeding unit has increased at a faster rate than crop production per acre of cropland.

to 1955, while the north-central and western divisions had increases in cropland area.

Changes in Crop Production per Acre

Trends in crop production per acre over the $3\frac{1}{2}$ decades up to 1955 have varied widely. The trend for the United States as a whole was flat from 1919 to the drought period of the 1930's, but since then it has been upward (fig. 4). This upward trend is strongly reflected in the annual rates of increase. During the World War II and immediate postwar period, crop production per acre increased at an annual rate of 1.2 percent, or more than twice that of the interwar period (table 10). The trend continued upward in the recent period, with crop production per acre increasing by 1.5 percent annually.

Increased crop production per acre was the second most important source of increase in farm output during the interwar period (1919-21 to 1938-40). A 9-percent increase was responsible for a third of the increased farm output. Yields per acre of such important crops as cotton and tobacco increased by about 50 and 25 percent, respectively.

Crop production per acre became the leading source of the increase in farm output for the United States during the World War II and immediate postwar period. Farm output increased 1.86 index points per year, of which 0.80 index point, or 43 percent, was due to the stepped-up outturn of crops per acre (table 9). The greater use of yield-improving practices was the chief factor responsible for the increase. The use of fertilizer increased by 3 million tons of plant nutrients, or 180 percent; the acreage of irrigated cropland increased by more than 8 million acres, or more than 40 percent; and the acreage of corn planted with hybrid seed changed from 35 percent in 1940-41 to about 85 percent in 1951-52.

From 1951-52 to 1955, greater crop production per acre continued to be the largest contributor to the change in farm output for the United States as a whole. An increase of 6 percent in crop production per acre was responsible for 46 percent of the increased farm output. On the average, weather was more favorable for raising crops in 1955 than in 1951-52, and the stepped-up use of yield-improving practices influenced the crop outturn per acre greatly.

TABLE 10.--Changes in crop production per acre, United States, specified periods, 1919-55

(1947-49 = 100)

Period	Index points	Percentage change	Annual rate of change
		Percent	*Percent*
1919-21 to 1938-40	7	9	0.5
1940-41 to 1951-52	12	14	1.2
1951-52 to 1955	6	6	1.5

SOURCES OF CHANGE IN UNITED STATES CROP PRODUCTION PER ACRE

The greater production of crops per acre has been an increasingly important source of added farm output since World War I. It has been the chief source of more farm production since World War II and promises to play an even greater role in the future. Some data are available for estimating the approximate magnitude of some of the major sources of greater crop production per acre. This section of the report is devoted to an analysis of this kind.

The general economic conditions of the overall national economy influence the changes in crop outturn per acre. In an expanding economy, continuous adjustments are needed in agriculture. Part of these adjustments are reflected in changes in aggregate crop production per acre. As consumer income rises, consumers tend to shift their diets from cereal grains and potatoes to vegetables, fruits, and livestock products. Thus, as farmers shift their production to meet these new demands of the consumer, the aggregate outturn per acre increases. Farmers tend to adopt new yield-increasing practices at a faster rate during periods of rising economic activity. Once farmers have made these adjustments, these practices tend to be nonreversible when economic conditions decline.

Many things have contributed to changes in average crop production per acre. These include changes in composition of crops grown, variations in weather, improved varieties of seed, greater use of fertilizer, irrigation, and improvements in pesticides. It is difficult to measure precisely the changing effect of any one of these factors because of interaction among the factors. With increased use of fertilizer per acre, for example, plant population per acre may be increased also. How much of the increase in production should be credited to fertilizer and how much to increased plant population cannot be ascertained exactly with the data available. The relative importance of fertilizer can be approximated, however. Moreover, as explained in a previous section, the contribution of change in crop production per acre to the change in total farm output can be measured rather accurately from the data developed in constructing the farm-output index. The method of constructing the farm-output index provides a measure of the total net effect of the various factors that contribute to changes in average outturn per acre and provides a necessary check when the approximations of contributions of individual factors are totaled.

Estimates of the contribution of specified factors to changes in crop production per acre for the United States during each of the three periods used in previous analyses and a combination of the two later periods are shown in table 11. In the sections that follow, each of these sources of changes in production per acre is discussed separately.

Composition

Composition of crop production is important in per acre changes in crop production and in farm output. On the United States basis, two types of changes in composition may affect average crop outturn per acre--changes in the crop "mix" of intensive and extensive crops produced, and shifts of cropland among regions. As the term is used in this report, "intensive crops" are those having higher than average value per acre; for instance, cotton, tobacco, rice, potatoes, and vegetables. "Extensive crops" are those with lower than average value per acre. Grain and

TABLE 11.--Annual changes in index points of crop production per acre, by source of change, United States, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1951-52	Change 1951-52 to 1955	Change, 1940-41 to 1955
Change in crop production per acre	0.26	0.80	0.92	0.82
Source of change:[2]				
Shift in cropland among regions	-.05	-.12	-.20	-.14
Shift in crops produced within regions	.05	.18	-1.27	-.17
Weather	-.11 to -.13	-.08 to -.12	.92 to 1.15	.16 to .20
Hybrid corn	.04 to .05	.09 to .14	.03 to .05	.08 to .12
Fertilizer	.06 to .09	.40 to .48	.55 to .64	.41 to .49
Irrigation	.01 to .02	.04 to .08	.05 to .09	.04 to .08
All other	.23 to .28	.20 to .28	.55 to .74	.33 to .41

[1] See table 9, footnote 1.
[2] Changes due to weather, hybrid corn, fertilizer, irrigation, and "all other" probably fall within range shown.

forage crops usually fall in this category. Theoretically, it is possible to have an increase in average production of crops per acre, even though yields of individual crops do not change. This increase would occur if there were an increase in the proportion of intensive crops produced or a relative shift of total cropland to regions with higher production per acre.

In general, except for the Pacific region, those west of the Mississippi River have the lowest aggregate crop production per acre. In all three periods, cropland tended to increase in these regions and to decrease in the eastern regions. As the proportion of the United States cropland in the lower-crop-production-per-acre regions has increased, the net effect has been to hold down average crop production per acre for the United States as a whole (table 12). In terms of index points, the negative effect increased in each period from the interwar to the recent period.

The role of variations in composition of crops produced in the change in average U. S. crop production per acre has varied in importance over time. During the interwar and World War II periods, intensive crops were emphasized. In the recent period, emphasis shifted to extensive crops (table 13).

The proportion of total crop production attributed to hay and grain crops decreased during the interwar period. These crops accounted for 62 percent of the total crop production in 1919-21 and for 54 percent in 1938-40. This decrease in relative proportion of total crop outturn from extensive crops meant that a larger share of all cropland was planted to such intensive crops as cotton, tobacco, and vegetables. Changes in crop mix were responsible for about one-fifth of the rise in aggregate crop production per acre and for 5 percent of the increased farm output.

During the World War II and immediate postwar years, the high-value crops continued to increase in importance. Consequently, the change in composition of crops produced was responsible for 23 percent of the stepped-up crop outturn per acre and for 10 percent of the increase in farm output.

Acreage-allotment programs were in effect in 1955 on such crops as cotton, tobacco, corn, and wheat. A large part of the acreage taken out of these crops was put in feed grains, which tend to yield less per acre. The net effect of these shifts in crops produced was to lower the aggregate United States production per acre.

TABLE 12.--Percentage distribution of cropland, and average value of crop production per acre of cropland used, United States and census regions, specified periods, 1919-55

Region[1]	Interwar			World War II and postwar			Recent		
	Crop production per acre 1919-21[2]	Proportion of total U. S. cropland		Crop production per acre 1940-41[3]	Proportion of total U. S. cropland		Crop production per acre 1951-52[3]	Proportion of total U. S. cropland	
		1919-21	1938-40		1940-41	1951-52		1951-52	1955
	Dollars	*Percent*	*Percent*	*Dollars*	*Percent*	*Percent*	*Dollars*	*Percent*	*Percent*
New England	28.99	1.2	1.0	89.51	1.0	0.8	110.97	0.8	0.7
Middle Atlantic	22.60	4.8	3.8	58.68	3.8	3.3	68.67	3.3	3.1
East north central	16.37	17.6	15.5	53.77	15.5	16.1	60.61	16.1	15.9
West north central	11.13	36.4	36.9	30.95	37.0	39.3	34.14	39.3	40.1
South Atlantic	25.11	8.4	7.9	73.96	7.7	6.9	99.76	6.9	6.5
East south central	20.18	7.2	7.1	58.09	7.2	5.7	71.59	5.7	5.6
West south central	15.61	13.8	15.7	40.28	15.6	13.1	45.23	13.1	13.1
Mountain	11.61	5.9	7.1	37.73	7.2	9.4	37.35	9.4	9.6
Pacific	22.16	4.7	5.0	88.03	5.0	5.4	109.06	5.4	5.4
United States	15.82	100.0	100.0	46.17	100.0	100.0	52.60	100.0	100.0

[1] For regional grouping of States, see table 2, footnote 1.
[2] Measured in average 1935-39 dollars.
[3] Measured in average 1947-49 dollars.

TABLE 13.--Average value of production per planted acre, and percentage of value of total crop production, major crops, United States, specified periods, 1919-55

Crop	Interwar			World War II and immediate postwar			Recent		
	Production per planted acre 1919-21[1]	Proportion of total crop production		Production per planted acre 1940-41[2]	Proportion of total crop production		Production per planted acre 1951-52[2]	Proportion of total crop production	
		1919-21	1938-40		1940-41	1951-52		1951-52	1955
	Dollars	*Percent*	*Percent*	*Dollars*	*Percent*	*Percent*	*Dollars*	*Percent*	*Percent*
Tobacco	140.60	4.2	4.7	456.77	3.7	5.2	591.10	5.2	4.9
Rice	28.38	.5	.6	110.40	.7	1.1	113.75	1.1	1.3
Cotton	19.39	11.1	11.2	85.53	12.1	13.4	96.42	13.4	12.5
Soybeans	0	0	0	44.07	1.4	3.7	52.53	3.7	4.5
Corn	17.66	30.4	24.4	43.77	22.7	23.3	56.11	23.3	23.3
Hay	9.62	12.0	11.8	29.42	12.7	12.0	31.79	12.0	12.0
Wheat	9.85	11.9	10.4	29.18	10.8	11.9	30.15	11.9	9.3
Barley	9.67	1.2	2.0	28.68	2.7	1.5	31.78	1.5	2.5
Oats	8.53	6.2	5.2	24.01	5.8	5.0	23.81	5.0	5.8
Sorghum grain	11.02	.7	.6	22.10	.8	.9	24.89	.9	1.6
All other	35.77	21.8	29.1	92.81	26.6	22.0	113.72	22.0	22.3
Average or total	15.82	100.0	100.0	46.17	100.0	100.0	56.65	100.0	100.0

[1] Measured in average 1935-39 dollars.
[2] Measured in average 1947-49 dollars.

Weather

Weather includes temperature and moisture. In addition, outbreaks of insect pests and diseases often are closely associated with variations in weather. The effect of weather on yields is not only a question of the amount of moisture or temperature, but of when the moisture came and when the temperature was high or low. In a season with rainfall that is limited in amount but comes at crucial periods of growth, bumper crops will be produced. All crops are not affected to the same degree by hot or cold weather.

The year-to-year changes in crop production per acre are due chiefly to weather, but over a longer period of time, changes in technology are more important. With the variations in climate that occur in the United States, only on rare occasions do widespread droughts, such as those of 1934 and 1936, reduce crop production appreciably for the country as a whole.

To derive a quantitative measure of the influence of weather, a regression line was computed for yields of the major crops in each region. The regression line was assumed to measure the effect of average weather and of changes in technology. When yields were above the regression line, weather was assumed to be better than average. The opposite was assumed if yields were below the regression line. These results checked fairly well with the overall weather conditions reported by the Crop Reporting Board of the Agricultural Marketing Service in its annual crop summaries for the years included in the analysis. Although the total influence of weather on crop production in the United States was calculated by adding regional weather influences, the data in figure 5 portray essentially the same results for the Nation as a whole.

Weather was above average at the beginning and slightly below average at the end of the interwar period for the United States as a whole. By 1938-40, most of the regions had recovered from the drought. Two notable exceptions were the west north-central and west south-central regions. In noting the weather of 1939, the Crop Reporting Board said, "In the Great Plains area, drought conditions still continued. These States . . . nearly a sixth of the acreage planted was lost and over large areas the yields were distressingly low

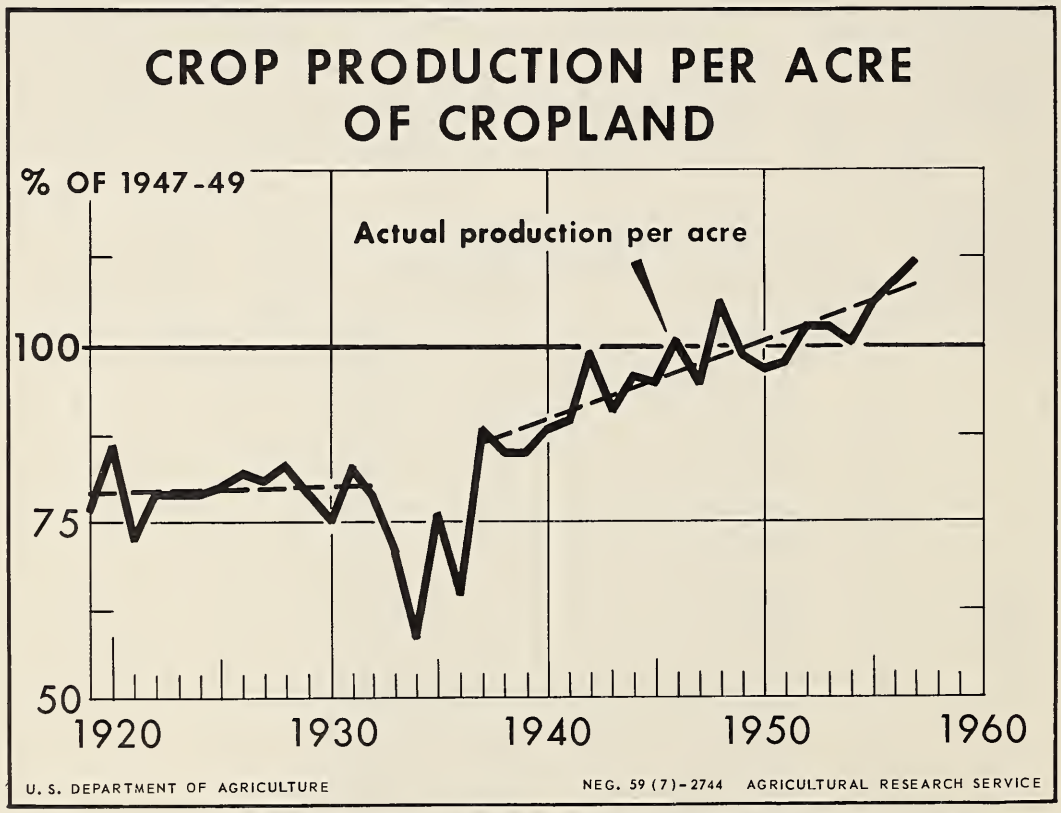

Figure 5.--Crop production per acre remained constant during the interwar period, but since the beginning of World War II it has increased.

(5, 1939)." Consequently, weather had the effect of lowering the average United States crop outturn per acre and farm output as a whole. This negative effect about offset the gains from added use of fertilizer and hybrid corn seed (table 11).

In 1951-52, weather in the United States was less favorable on the average than at the beginning of World War II. On a percentage basis, the negative influence was less than in the interwar period. Still, the effect of weather was enough to offset the increase in production from the stepped-up use of hybrid corn seed. The negative effect of weather on crop outturn per acre in the United States was due chiefly to less favorable weather in the east and west south-central and mountain regions.

Citrus groves in Texas and Louisiana sustained very heavy damage from a freeze in February 1951, and as a result, commercial production of citrus fruit was negligible. During the same year, the Crop Reporting Board observed that losses in acreage planted of all crops for the United States as a whole more than doubled the average losses in 8 of the 10 previous years. In fact, except for the drought years 1933, 1934, and 1936, these acreage losses were the heaviest for any of the previous 20 years. More than half of the losses were in the winter wheat areas and losses were relatively heavy in the cotton area (5, 1951).

More favorable weather in 1955 than in 1951-52 was of major importance for the upward push to crop production per acre and total farm output. In 1955, an unusual number of crops made record yields in the United States. New records to that date were attained by oats, rice, cotton, hay, tobacco, sugar beets, potatoes, and sweetpotatoes. Rains early in the season brought adequate soil moisture to many producing areas in which drought had persisted in 1954 (5, 1955). The positive effect of weather was about enough to offset the negative effects of changes in composition of crop production.

Hybrid Corn Seed

Research has given us new and improved seeds with which to increase our crop outturn per acre. As suitable data on improved varieties are not available, hybrid corn seed was selected to illustrate the relative importance of improved seeds in increasing crop production per acre and adding to farm output. Use of hybrid corn seed usually increases the yield of corn per acre by about 20 percent compared with the use of open-pollinated varieties. As corn alone accounts for more than a fifth of the total crop production of the United States, it is apparent that hybrid seed has had an important influence on aggregate outturn per acre.

The interwar period might be called the introduction period for hybrid corn seed. Less than 1 percent of the acreage of corn in the United States was planted with hybrid seed in 1933, all in the north-central division. By 1940, acreages of hybrid corn were reported in all regions. In the United States as a whole, 30 percent of the corn acreage was planted with hybrid seed. Consequently, 15 to 20 percent of the increased crop outturn per acre came from this source (table 11).

The use of hybrid corn seed increased rapidly from the beginning of World War II to the Korean conflict. New hybrid varieties adapted to growing conditions in the various regions were developed. The early varieties were best adapted to growing conditions in the Corn Belt. By 1951-52, more than 80 percent of the acreage of corn in the United States was planted with hybrid seed. On a volume basis, hybrid corn seed contributed twice as much to the increased crop outturn per acre as it did during the previous period, although its contribution was smaller on a percentage basis.

Hybrid corn was less important on a percentage basis as a source of increased crop production from 1951-52 to 1955 than in the two previous periods. The stepped-up use of hybrid seed contributed between 3 and 5 percent of the increased crop outturn. By 1952, in the major corn-producing areas of the east north-central and west north-central regions, 99 and 95 percent, respectively, of their corn acreages were planted to hybrid seed. Thus, most of the increased use of hybrid seed came from regions outside the major corn-producing areas. For the United States as a whole, the corn acreage planted to hybrid seed increased from a little more than 80 to about 90 percent in 1955. The volume of the increased crop outturn that can be attributed to hybrid corn seed during the recent period was only a third as large as it was in the World War II and the immediate postwar years. However, it was equal to the volume contributed during the interwar period.

Fertilizer

Chemical fertilizers have supplemented or replaced legume crops and manure as

farmers have attained progressively higher yields per acre. Scientists have learned to establish and maintain optimum levels of plant nutrients in soils. They have found that wornout land can be restored and made more productive than it was when cleared of timber or broken from native sod.

Consumption of commercial fertilizer nutrients showed a continuing upward trend from 1919 to 1955 (fig. 6). There was only a moderate increase during the interwar years. But from the beginning of World War II to 1955, the trend was sharply upward. According to the 1954 Census of Agriculture, tobacco and sugar beets lead the list of crops in acres fertilized, with 97 and 90 percent, respectively. Sixty percent of the acreage of corn and 55 percent of the acreage of cotton were fertilized.

Fertilizer has been the major single source of our stepped-up crop output per acre in each of the three periods (table 11). The rate of increase in the use of fertilizer is reflected in the general economic condition of farmers. During the interwar period, when prices paid for fertilizer tended to become "dearer" relative to prices received for crops, the fertilizer used increased more slowly than in the decade and a half following 1940, when fertilizer prices became increasingly "cheap" relative to crop prices (table 14).

From 1919-1921 to 1938-40, fertilizer was responsible for more than a fourth of the increased crop production per acre and a tenth of the change in total farm output for the United States as a whole. The largest share of the increase from this source came from the regions along the Atlantic coast. During this period, national consumption of commercial fertilizers rose from 943,000 to 1,550,000 tons, or by 65 percent. Thus, for each ton of plant nutrients used there were 400 acres of cropland in 1919-21 and 240 acres in 1938-40.

The relative importance of fertilizer as a source of increased crop production in the United States more than doubled during the World War II and immediate postwar years compared with the previous period, but in absolute terms, the contribution was five times that of the earlier period. More than half of the stepped-up crop outturn and more than a fifth of the additional farm output came from this source. The consumption of fertilizer increased rapidly--from 1.8 to 4.9 million tons of plant

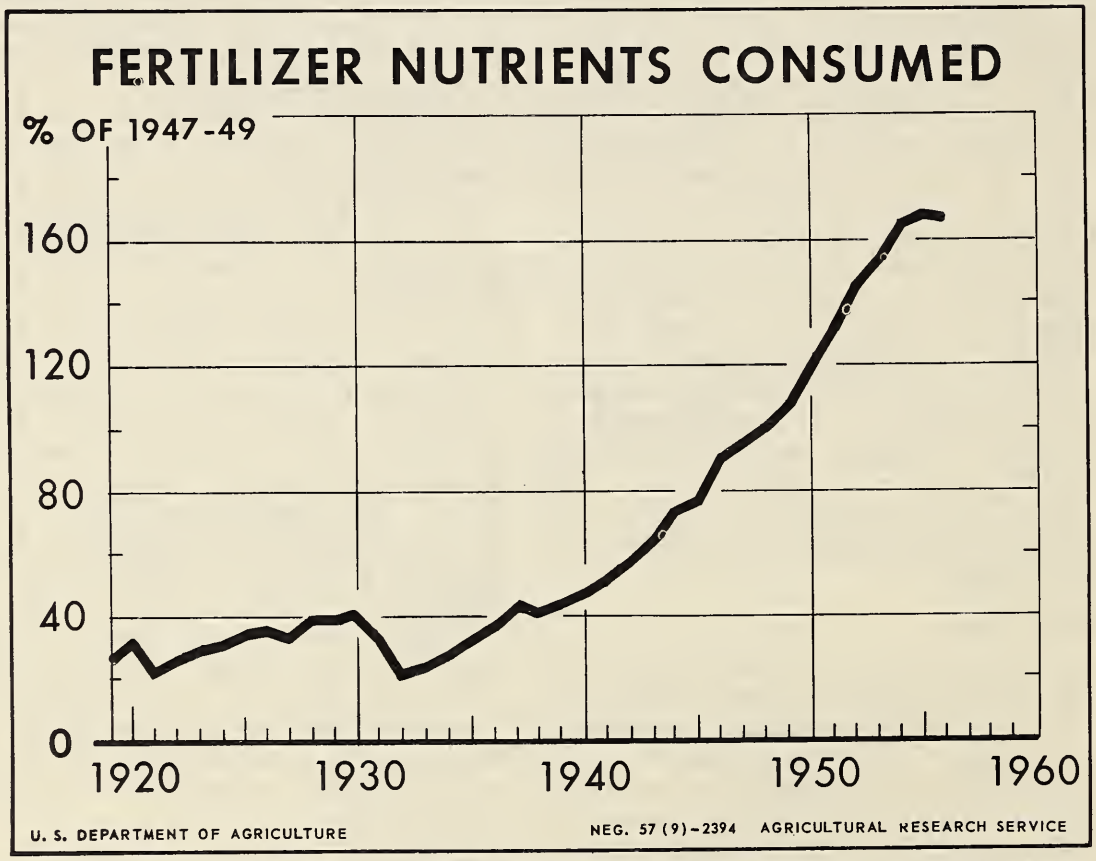

Figure 6.--Since the depression of the 1930's, consumption of fertilizer nutrients has trended sharply upward.

TABLE 14.--Acres of cropland used for crops per ton of plant nutrients, and related data, United States, specified periods, 1919-55

Period	Fertilizer nutrients	Cropland		Ratio of prices received for crops to prices of fertilizer (1910-14=100)
		Total	Per ton of nutrients	
	1,000 tons	*Million acres*	*Acres*	
1919-21	943	371	393	1.14
1938-40	1,549	368	238	.84
1940-41	1,757	368	209	1.01
1951-52	4,925	381	77	1.73
1955	5,996	377	63	1.55

nutrients. For the United States as a whole, 1 ton of plant nutrients was used per 77 acres of cropland in 1951-52, compared with 209 acres in 1940-41.

Fertilizer contributed two-thirds of the increase in crop production per acre from 1951-52 to 1955 and more than a fifth of the added farm output in the United States. The use of fertilizer continued its sharp upward trend of the previous period. The number of acres of cropland per ton of plant nutrients continued to decline. By 1955, a ton of commercial plant nutrients was used on every 63 acres of cropland in the United States. The middle Atlantic and east and west north-central regions, combined, accounted for about three-fourths of the increase in crop production per acre that resulted from greater use of fertilizer in the country as a whole.

Irrigation

In parts of this country, land has been under irrigation for more than a century. Practically all of the western specialty-crop farming areas are on irrigated land. In the last two decades, irrigation has spread to the humid East. About an eighth of all crop production in the United States depends wholly or partly on irrigation.

Irrigation has tended to increase crop production per acre. The Special Report on Irrigation of the 1950 Census of Agriculture reported increases in yield on irrigated over nonirrigated acreages of 50 to 300 percent, varying by crops. The amount by which irrigation increases crop production varies from year to year, depending on rainfall and water supplies. Increased use of irrigation is usually accompanied by greater use of such yield-improving practices as fertilizer, pesticides, and greater plant population per acre. In estimating the contribution of irrigation to the change in farm output, the cost of these other improved practices was deducted from the total value of production attributed to irrigation and associated improved practices. In developing quantitative estimates of the effects of irrigation on production, it was estimated that, owing to the water added, average crop production per irrigated acre would increase about 30 percent in the regions east of the Mississippi River and about 50 percent in those west of the Mississippi.

These calculations indicate that irrigation accounted for 5 to 10 percent of the increase in U. S. crop production per acre in each of the three periods considered. During the interwar period, irrigated acreage increased from 14 to 18 million acres, or 1 percent per year (table 15). Essentially all of this increase came in the western division. In 1940, only 1 percent of all irrigated acreage in the United States was east of the Mississippi River.

During the World War II and recent periods, the acreage of irrigated lands increased about 3.5 percent annually. The total acreage located in the East stepped up to 2 percent in 1950 and 3 percent in 1954. Although irrigation contributed the same relative proportion to the change in crop production per acre, on a volume basis, irrigation contributed three times as much per year during the latter two periods as during the interwar period (table 11).

TABLE 15.--Irrigated land in farms, United States, specified years, 1920-54[1]

Region[2]	1920	1940	1950	1954
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*
East	--	160	510	971
West	14,350	17,823	25,277	28,582
United States	14,350	17,983	25,787	29,553

[1] Based on data from censuses of agriculture, except that data for areas irrigated in 1920 were interpolated from census of irrigation.

[2] East includes the New England; middle Atlantic, south Atlantic, east south-central, and east north-central regions. West includes the west north-central, west south-central, mountain, and Pacific regions. For regional groupings of States, see table 2, footnote 1.

Other Factors

Many other factors influence changes in crop production; for example, drainage, land selectivity, soil conservation practices and soil improvement, improved seed, more timely operations, pesticides, lime, and plant population. The net effect of all other sources and any error, plus or minus, of the estimates of individual sources measured above is included in the "all other" category in table 11. Although these additional sources of greater production are important individually, the lack of data with which to measure their relative importance makes it necessary to measure them together.

Drainage has been an important method of increasing the productivity and acreage of cropland during the $3\frac{1}{2}$ decades since World War I. The total acreage in organized drainage enterprises in the United States reached 100 million acres in 1950, compared with 66 million in 1920 and 87 million in 1940 (11). The east and west north-central regions have the largest acreages in organized drainage enterprises.

Such soil conservation practices as contour operations, terracing, and use of green manure and cover crops not only lessen the damage from water erosion but hold the water. These practices were the exception rather than the rule only a few years ago. More than 90 percent of all farms in the United States in 1957 were located within the boundaries of a Soil Conservation District.

Greater use of improved seed varieties has helped to increase average crop production per acre, as illustrated by hybrid corn seed. The influence of all improved seed is probably more important than hybrid corn seed alone. In 1955, for example, 70 percent of all cropland was planted to varieties of crops not in existence 20 years earlier. In the space of two decades, seed varieties used in planting cotton, and oil and sugar crops changed almost completely. Varieties of hay seed changed the least--and hay yields increased less than yields of other crops (7).

No doubt, new organic insecticides that were unavailable until the end of World War II have had a marked effect on crop production per acre, and especially on the production of potatoes, onions, and sweet corn. The use of these insecticides increased from 33 million pounds in 1945 to about 10 times that amount in 1955. More than 1.6 million acres of rangeland were sprayed aerially with insecticides for the control of grasshoppers in 1955.

The shift from horse and mule power to mechanical power has meant more timeliness in farm operations. The effect of mechanization on production cannot be measured precisely because of the timeliness factor in farm operations. Yet there is evidence to point to greater production and higher quality of product because of better timing of operations. The real advantages often come when working conditions are adverse. These are the critical times when the difference in equipment and power means the difference between little or no crop and a large crop.

Lime has increased crop yields greatly. More than 6 million tons of lime were used in this country in 1955, compared with 2 million tons in 1940-41 and less than a million tons in 1919-21.

These varied sources of increase in crop production per acre as a group were im-

portant in all three periods. The combined effect of these sources was greater than the effect of any single factor studied during the interwar period. They ranked second in the two periods that followed. The net effects of these sources of greater production were of major importance in all parts of the country in all three periods.

SOURCES OF CHANGES IN REGIONAL FARM OUTPUT AND PRODUCTION PER ACRE

In the previous sections, analyses were made of the sources of changes in farm output and crop production per acre in the United States. In the following sections, similar analyses are made for the various regions. Sources of regional changes may vary greatly from those for the United States as a whole. For example, one region may shift to mechanical power faster than other regions.

Northeastern Division

In the northeastern division since World War I, livestock production, mainly dairy and poultry production, has tended to increase rapidly and crop production has remained fairly constant. In the short run, crop production has varied widely from one year to the next (fig. 7). As described here, the northeastern division is composed of the New England and the middle Atlantic regions.

During the interwar period, farm output was stepped up gradually in the New England region; the increase averaged about 0.5 index point per year (fig. 7). But between 1940-41 and 1955, farm output rose by about one index point per year (table 16). Following the initial increase at the start of World War II, farm output has been relatively constant.

The number of horses and mules on farms in New England decreased from 305,000 in 1919-21 to about 47,000 in 1955. The release of resources used to maintain horses and mules increased farm output available for human use. The reduction of farm-produced power was of leading importance as a source of increased output

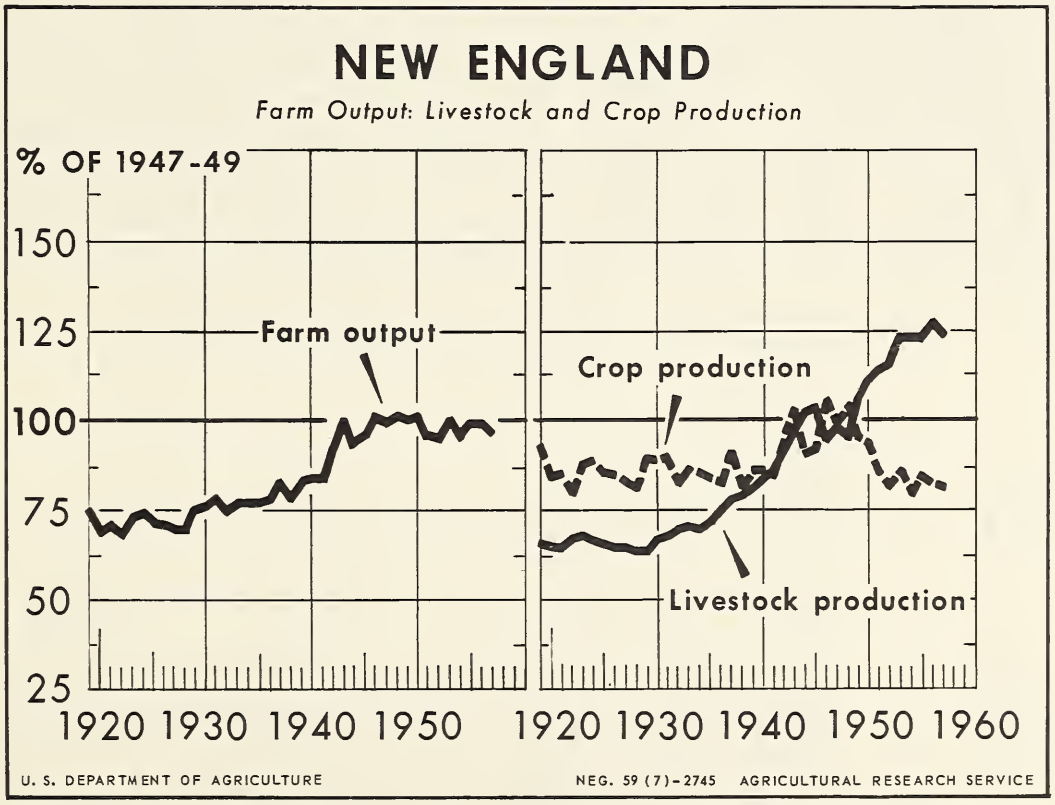

Figure 7.--In New England since the 1920's the relative importance of livestock production in total farm output has increased.

TABLE 16.--Annual changes in index points of farm output, by source of change, New England region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.46	86	0.33	33	0.32	28	0.33	32
Change in product added by all livestock.	.17	33	.74	74	.62	54	.72	70
Change in pasture consumed by all livestock.....	-.02	-4	.01	1	.16	14	.04	4
Change in cropland used.....	-.57	-107	-1.40	-140	-3.86	-338	-1.90	-185
Change in crop production per acre.....	.49	92	1.32	132	3.90	342	1.84	179
Total change in farm output.....	.53	100	1.00	100	1.14	100	1.03	100

[1] Includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.

during the interwar period in New England. From the beginning of World War II to 1955, the relative importance of this source decreased on a volume basis and also relative to total change in farm output.

As indicated in figure 7, livestock production increased slowly compared with that during the World War II and recent years. This increase is reflected in the relative importance of product added and pasture consumed by livestock as sources of added farm output. The relative proportion of the total increase in farm output from these sources was more than twice as important in the latter as in the earlier period. On a volume basis, product added and pasture consumed by livestock contributed close to five times more in the latter period.

Except for a few years during World War II, the net effect of changes in cropland used for crops and in crop production per acre has been to maintain total crop production at a relatively constant level. The acreage of cropland in New England trended sharply downward from 1919 to 1955. About half as much acreage was used in 1955 as in 1919 and a third less than in 1940. Thus, changes in acreage of cropland had a negative effect on output throughout the period. Crop production per acre moved in the opposite direction, but not enough to offset the negative effect of the decrease in acreage of cropland. Crop production per acre increased by 20 percent during the interwar period, and by more than 60 percent from 1940-41 to 1955.

Crop production per acre added 0.49 index point a year to the increased output during the interwar period and 1.84 index points from 1940 to 1955. About a fourth of the increase in both periods came from such yield-affecting practices as use of hybrid corn, increase in amount of fertilizer used, and use of irrigation (table 17).[9] Changes in weather and in composition of crops grown had little effect in either period. The increase in crop outturn per acre was due chiefly to the other factors.

In the middle Atlantic region, farm output remained fairly constant after World War I until the midthirties, after which it tended to rise (fig. 8). During the interwar period, farm output increased 10 percent or less than half of an index point per year (table 18). As economic conditions improved during World War II and the immediate postwar years, farm output increased 22 percent, or about 1.4 index points annually.

Horse and mule numbers decreased by about a half-million head during the interwar period and again from 1940-41 to 1955. On a volume basis, the reduction of farm-produced power contributed about the same amount in both periods to the increase in farm output--one-half of an index point per year.

Livestock production in this region, as shown in figure 8, has the same long-term trend as in New England. As the rate of production increased, the importance of product added and pasture consumed by livestock as sources of stepped-up farm output increased. On a volume basis, the

[9] Yield-affecting practices in this section refer to increased use of hybrid seed corn, fertilizer, and irrigation.

TABLE 17.--Annual changes in index points of crop production per acre, by source of change, New England, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre.....	0.49	1.84
Source of change:[2]		
Composition.....	.05	.07
Weather.....	0 to -.04	.02 to .06
Specified yield-affecting practices[3].....	.10 to .14	.44 to .46
All other.....	.32 to .36	1.25 to 1.29

[1] Includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

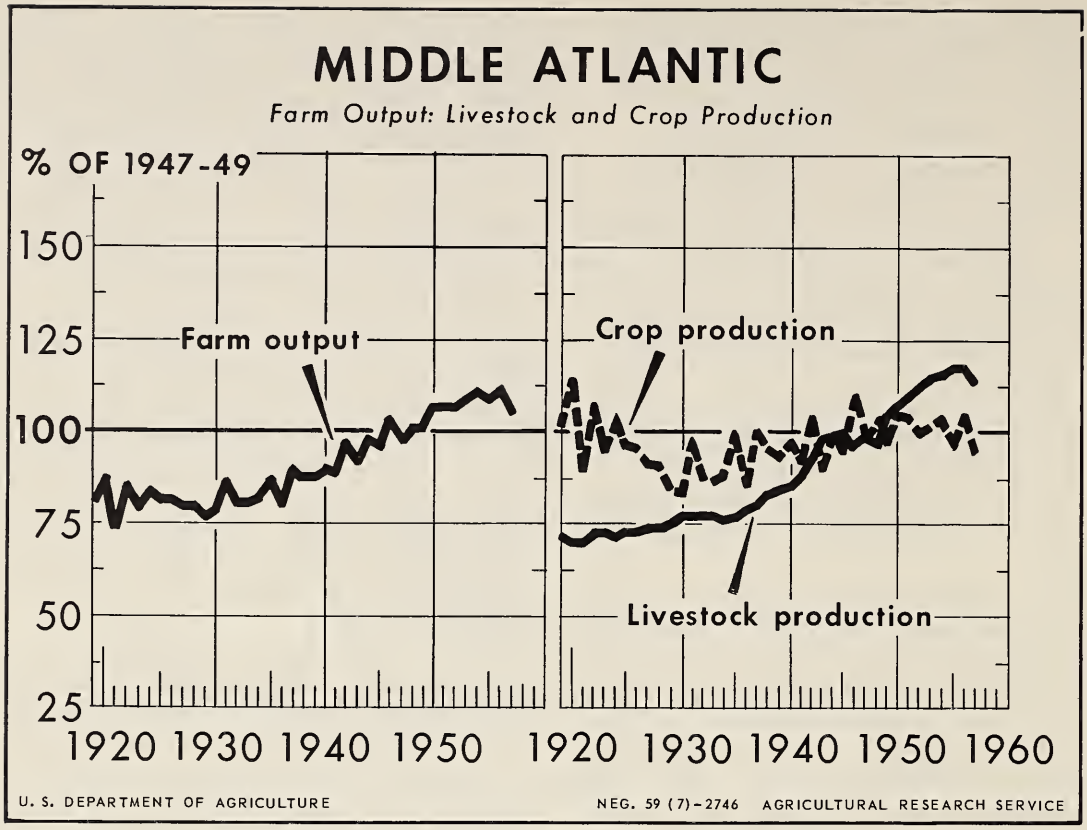

Figure 8.--In the middle Atlantic region, the increase in livestock production has been greater than the increase in crop production.

annual contribution of product added and of pasture consumed was six times greater in the recent period than in the interwar period. The relative proportion of the change in farm output from these sources nearly doubled in the latter period compared with that in the earlier one.

Total crop production in the middle Atlantic region tended to decline during the 1920's. Most of the decline was regained during the 1930's and early forties. Since the midforties, crop production has remained fairly constant. The same divergent trends in cropland and crop production per acre occurred in this region as in New England. Cropland used for crops declined in both periods and thus had a negative effect on both total crop production and farm output.

During the interwar period, crop production per acre increased though not enough to offset the negative effects of a decrease in acreage of cropland. Most of the increase was due to a shift to production of such high value crops as vegetables and dry beans (table 19). Stepped-up use of hybrid corn, fertilizer, and irrigation accounted for a fourth of the added crop outturn per acre.

From 1940-41 to 1955, stepped-up crop production per acre was sufficient to offset the effects of the reduction in cropland. Crop production per acre added 0.84 farm output index points per year. Weather was less favorable in 1955 than in 1940-41, and there was a shift to less intensive crops. Thus these two factors had the effect of holding down crop outturn per acre and farm output. Yield-affecting practices and all other factors were about equally important. Fertilizer was increased from 65 acres per ton of plant nutrients in 1940-41 to about 20 acres in 1955.

North-central Division

The north-central division, which includes the east north-central and the west north-central regions, may be characterized as an area in which farm output has tended to increase over the long run. Farm output and livestock and crop production were greatly influenced by the drought of the 1930's. Livestock production has had an overall upward trend during the last $3\frac{1}{2}$ decades. In contrast to livestock production, crop production had no definite trend during the 1920's. Then the droughts of the 1930's held down production. Since the

TABLE 18.--Annual changes in index points of farm output, by source of change, middle Atlantic region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.52	122	0.62	38	0.34	60	0.55	40
Change in product added by all livestock.	.10	24	.59	36	.53	94	.59	43
Change in pasture consumed by all livestock.....	0	([2])	.08	5	.22	38	.11	8
Change in cropland used.....	-.76	-180	-.52	-32	-1.28	-225	-.71	-52
Change in crop production per acre.....	.56	134	.87	53	.76	133	.84	61
Total change in farm output.....	.42	100	1.64	100	.57	100	1.38	100

[1] Includes New York, Pennsylvania, and New Jersey.
[2] Less than 0.5 percent.

TABLE 19.--Annual changes in index points of crop production per acre, by source of change, middle Atlantic region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre.....	0.56	0.84
Source of change:[2]		
Composition.....	.31	-.24
Weather.....	.02 to -.02	-.31 to -.35
Specified yield-affecting practices[3].....	.14 to .18	.65 to .69
All other.....	.07 to .11	.72 to .76

[1] Includes New York, Pennsylvania, and New Jersey.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation practices.

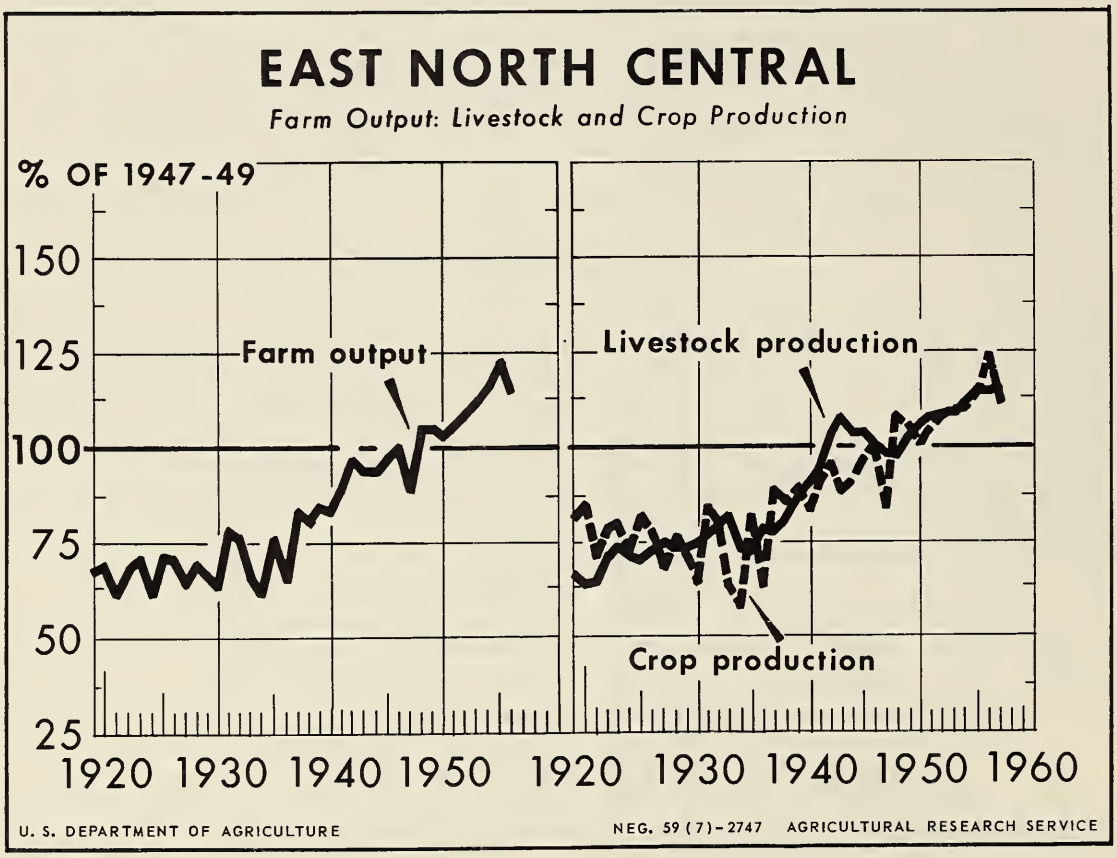

Figure 9.--Crop production and livestock production have tended to move together in the east north-central region.

early forties, crop production has been stepped up in the east north-central region, while it has remained fairly constant but at a higher level than previously in the west north-central region. The total acreage of cropland used for crops in the area as a whole has increased slightly. Crop output per acre has risen moderately.

During the interwar period, farm output increased 25 percent in the east north-central region (fig. 9). The major source of added farm output was the increase in crop production per acre (table 20), which was due chiefly to a shift to more intensive crops (table 21). Hybrid corn seed probably accounted for a fifth of the increase. The

TABLE 20.--Annual changes in index points of farm output, by source of change, east north-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.41	46	0.50	25	0.21	8	0.43	20
Change in product added by all livestock.....	.22	25	.32	16	.31	12	.32	15
Change in pasture consumed by all livestock.....	.04	5	.02	1	.15	6	.04	2
Change in cropland used.....	-.41	-46	.44	22	-.26	-10	.26	12
Change in crop production per acre.....	.63	70	.72	36	2.16	84	1.09	51
Total change in farm output.....	.89	100	2.00	100	2.57	100	2.14	100

[1] Includes Ohio, Indiana, Illinois, Michigan, and Wisconsin.

TABLE 21.--Annual changes in index points of crop production per acre, by source of change, east north-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre	0.63	1.09
Source of change:[2]		
Composition	.38	-.03
Weather	.02 to .06	.18 to .22
Specified yield-affecting practices[3]	.14 to .18	.72 to .76
All other	.03 to .07	.16 to .20

[1] Includes Ohio, Indiana, Illinois, Michigan, and Wisconsin.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

decline in number of farm horses and mules of nearly 2 million head was the second most important source of increased farm output. However, this increase was offset by the decline in farm output caused by a decrease in the number of acres of cropland used for crops. The increased production of livestock feed crops (feed grains, hay, and forage) made it possible to increase livestock production. This increase in livestock production was reflected in the relative importance that the increased product added and pasture consumed by livestock had on the total change in farm output. Together, they accounted for 30 percent of the step-up in farm output.

From 1940 to 1955, inclusive, farm output increased by a third, or more than 2 index points per year. Again, the change in crop production per acre was the major source of the increase; it accounted for half the increase in farm output or above 1 index point per year. Two-thirds of this increase came from adoption of two yield-affecting practices--use of hybrid corn seed and greater use of fertilizer. In 1940-41, 243 acres of cropland were used to each ton of plant nutrients, but by 1955 the number had decreased to 43 acres to each ton of plant nutrients. Improved weather in 1955 compared with that of 1940-41 accounted for nearly a fifth of the added crop outturn per acre. The acreage of cropland used for crops increased during this period. Thus, instead of having a negative effect on output as in the earlier period, the larger acreage of cropland was responsible for 10 percent of the added farm output. The number of horses and mules declined as much in this 15-year period as in the previous 20-year period. The release of resources used for farm-produced power continued as the second most important source of greater farm output. Total livestock production continued to increase. Thus product added and pasture consumed by livestock remained important factors in the increase in farm output.

Farm output increased by only 10 percent during the interwar years in the west north-central region (fig. 10). The modest increase was due chiefly to the reduction in farm-produced power (table 22). Horse and mule numbers declined from 7.8 million head in 1919-21 to 4.0 million in 1938-40. Total crop production was smaller at the end than at the beginning of the period. This was due to a smaller crop outturn per acre of more than 5 percent. The reduction in farm output resulting from less crop production per acre was great enough to offset the modest increases that came from the increased acreage of cropland and greater livestock production.

By 1938-40, farm output in this region had not recovered fully from the severe droughts of the 1930's. The poorer weather at the end of the period was great enough to offset the gains in crop production per acre, owing to increased use of hybrid corn seed and fertilizer (table 23). Probably, livestock production was less than it normally would have been, owing to the reduction of cattle numbers during the drought period. Thus, weather was important in keeping output at a lower than normal level.

TABLE 22.--Annual changes in index points of farm output, by source of change, west north-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.50	136	0.52	24	0.34	30	0.48	25
Change in product added by all livestock.....	.04	11	.48	22	1.06	93	.62	32
Change in pasture consumed by livestock.....	.03	7	-.02	-1	.24	21	.04	2
Change in cropland used.....	.02	4	.59	27	.33	29	.52	27
Change in crop production per acre.....	-.22	-58	.61	28	-.83	-73	.27	14
Total change in farm output.....	.37	100	2.18	100	1.14	100	1.93	100

[1] Includes Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.

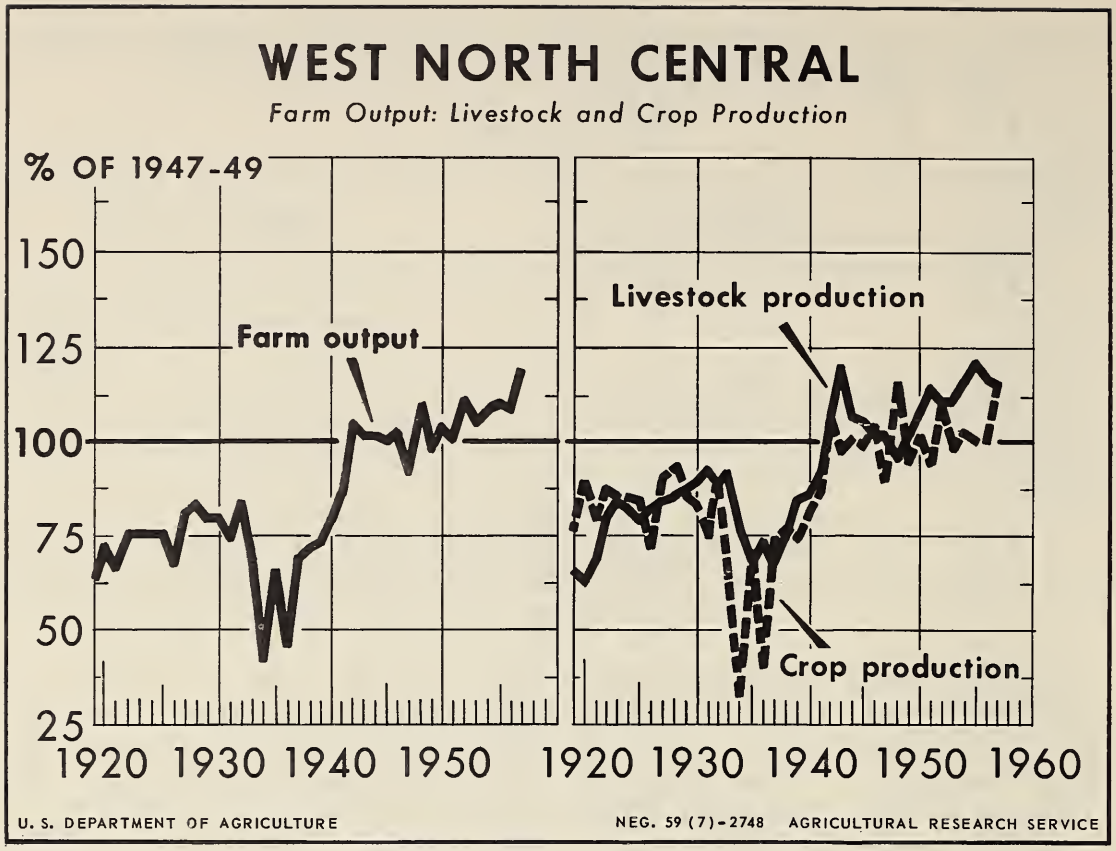

Figure 10.--The drought of the 1930's affected farm output in the west north-central region more than in any other area.

TABLE 23.--Annual changes in index points of crop production per acre, by source of change, west north-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre	-0.22	0.27
Source of change:[2]		
Composition	-.10	-.02
Weather	-.28 to -.32	-.40 to -.44
Specified yield-affecting practices[3]	.06 to .10	.51 to .55
All other	.08 to .12	.16 to .20

[1] Includes Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

From the end of the interwar period to 1955, the west north-central region stepped up farm output by a third, or about 2 index points per year. Increased livestock production was the leading source of the added farm output; it accounted for more than a third of the increase. Reduction in farm-produced power continued to play an important role in the change in farm output; it contributed a fourth of the change. Total crop production increased by about one-fifth. This gain was due to an increase in cropland and to greater crop outturn per acre. The acreage of cropland used for crops was 10 percent greater in 1955 than in 1940-41, thus accounting for more than

a fourth of the added farm output. Crop outturn per acre increased by more than 5 percent and was responsible for one-seventh of the change in farm output in the west north-central region. Yield-affecting practices were the major factors in the greater crop outturn per acre. In 1940-41, a ton of fertilizer nutrients was used for each 3,762 acres of cropland. By 1955, the number of acres per ton had declined to 186. Weather again had the effect of lowering crop yields in 1955 compared with those of 1940-41.

Southern Division

The southern division, which is composed of the south Atlantic, east south-central, and west south-central regions has had a continuing upward trend in farm output since World War I. Livestock production increased moderately during the interwar period. But from 1940 to 1955, livestock output increased rapidly, especially in the south Atlantic region. Total crop production moved upward slowly throughout the period. Increased crop outturn per acre has more than offset the negative effect of the declining number of acres used for crops.

The south Atlantic region had the sharpest upward trend in farm output of the southern division (fig. 11). During the interwar period, farm output increased by a fourth, or about one index point per year (table 24). Change in crop production per acre was the leading source of the stepped-up farm output. Crop outturn per acre increased by more than 25 percent, mainly because of factors other than weather, composition, and yield-affecting practices. The acreage of cropland used for crops declined by 8 percent but the decline had a negative effect on output. Reduction in farm-produced power was the second major source of stepped-up farm output; it accounted for nearly 30 percent. Horse and mule numbers declined by more than 600,000 head, thus releasing resources for production for human use. Increases in product added by livestock were responsible for more than 10 percent of the added farm output.

From 1940 to 1955, farm output increased by 40 percent, or 2.3 index points, per year. Again, as in the earlier period, change in crop production per acre was the leading source of change in farm output. But this time, yield-affecting practices

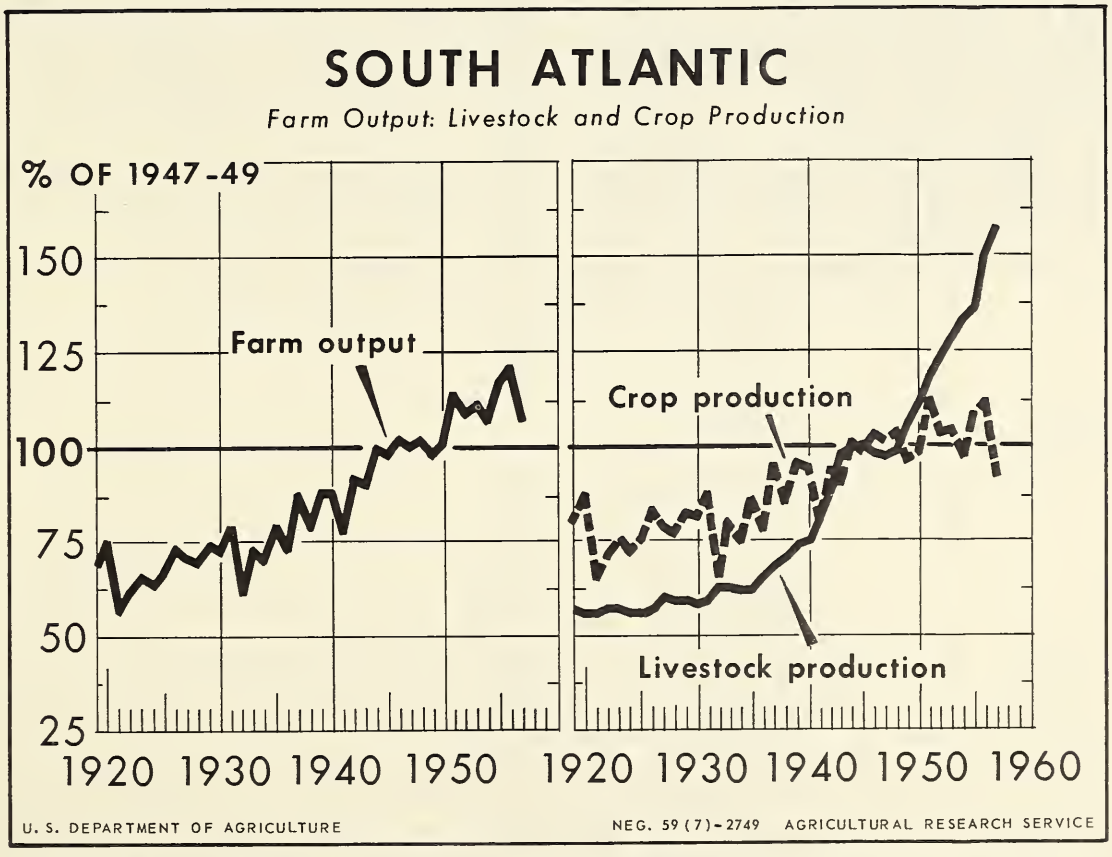

Figure 11.--Farm output increased at a faster rate in the south Atlantic region than in any other southern region.

TABLE 24.--Annual changes in index points of farm output, by source of change, south Atlantic region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.28	29	0.37	14	0.57	40	0.44	19
Change in product added by all livestock..	.10	11	.55	21	.50	35	.54	23
Change in pasture consumed by livestock...	0	(2)	.05	2	.12	8	.07	3
Change in cropland used.....	-.27	-28	-.63	-24	-1.36	-95	-.86	-37
Change in crop production per acre.....	.84	88	2.30	87	1.60	112	2.15	92
Total change in farm output.....	.95	100	2.64	100	1.43	100	2.34	100

[1] Includes Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida.
[2] Less than 0.5 percent.

and improved weather were the major cause of the increase in crop outturn per acre (table 25). Total production of livestock increased at a rapid rate, which was reflected in the greater relative importance that product-added assumed in the increase in farm output. Product added and pasture consumed by livestock accounted for a fourth and was the second most important source of the greater farm output. Farm-produced power continued to decline and thus added to the volume of production for human use.

Farm output in the east south-central region was a fifth greater in 1938-40 than in 1919-21 (fig. 12), mainly from greater crop production per acre (table 26). Crop production per acre rose by more than 10 percent, whereas acreages of cropland used for crops decreased. The net increase in total crop production accounted for half of the larger farm output. The increase in crop production per acre was due chiefly to factors other than yield-affecting practices, weather, and changes in composition. The latter two had a negative effect on output. Fertilizer was the chief individual factor; its increased use contributed about half of the added crop outturn per acre.

Reduction in farm-produced power during this period was the second most important source; it contributed more than 40 percent of the greater output. A moderate increase in livestock production accounted for 10 percent of the additional production for human use.

From 1940-41 to 1955, farm output in the east south-central region increased by a third, and at the rate of 1.9 index points per year. The acreage of cropland used for crops decreased by more than 15 percent. The decline in farm output from this source was great enough to offset the gains in output caused by a continuing reduction in farm-produced power and stepped-up livestock production. Thus, the increase in farm output was equal to the increase that was due to greater crop production per acre.

Crop production per acre was 40 percent greater in 1955 than in 1940-41. Improved weather was the leading reason (table 27). Change in composition of crops produced continued to have a lowering effect on output. For example, the acreage of cotton--a crop of high value per acre--declined from 5.2 to 3.4 million acres. Increased use of fertilizer about offset the reduction in crop outturn per acre caused by changes in composition.

Farm output in the west south-central region rose by less than a fifth during the interwar period (fig. 13). The leading source of this increase came from the reduction of farm-produced power (table 28). Horse and mule numbers declined by 1.8 million head, but tractor numbers increased by 150,000. This region was the only one of the southern division to increase its acreage of crops during the interwar period. The acreage of cropland used increased by 14 percent. As a result, this was the second most important source of greater output. From 1919-21 to 1938-40, crop production per acre declined by 8 percent. The west south-central and the west north-central regions were the only ones in which crop production per acre

TABLE 25.--Annual changes in index points of crop production per acre, by source of change, south Atlantic region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre	0.84	2.15
Source of change:[2]		
Composition	.06	-.17
Weather	.02 to -.02	.71 to .75
Specified yield-affecting practices[3]	.10 to .14	.84 to .88
All other	.64 to .68	.71 to .75

[1] Includes Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida.

[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.

[3] Includes hybrid seed corn, fertilizer, and irrigation.

TABLE 26.--Annual changes in index points of farm output, by source of change, east south-central region, specified periods. 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.31	42	0.49	45	1.03	24	0.61	33
Change in product added by all livestock..	.06	8	.43	39	.60	14	.47	25
Change in pasture consumed by livestock...	.02	3	.05	5	.09	2	.06	3
Change in cropland used.....	-.10	-13	-1.33	-122	-.69	-16	-1.14	-61
Change in crop production per acre.....	.45	60	1.45	133	3.26	76	1.86	100
Total change in farm output.....	.74	100	1.09	100	4.29	100	1.86	100

[1] Includes Kentucky, Tennessee, Alabama, and Mississippi.

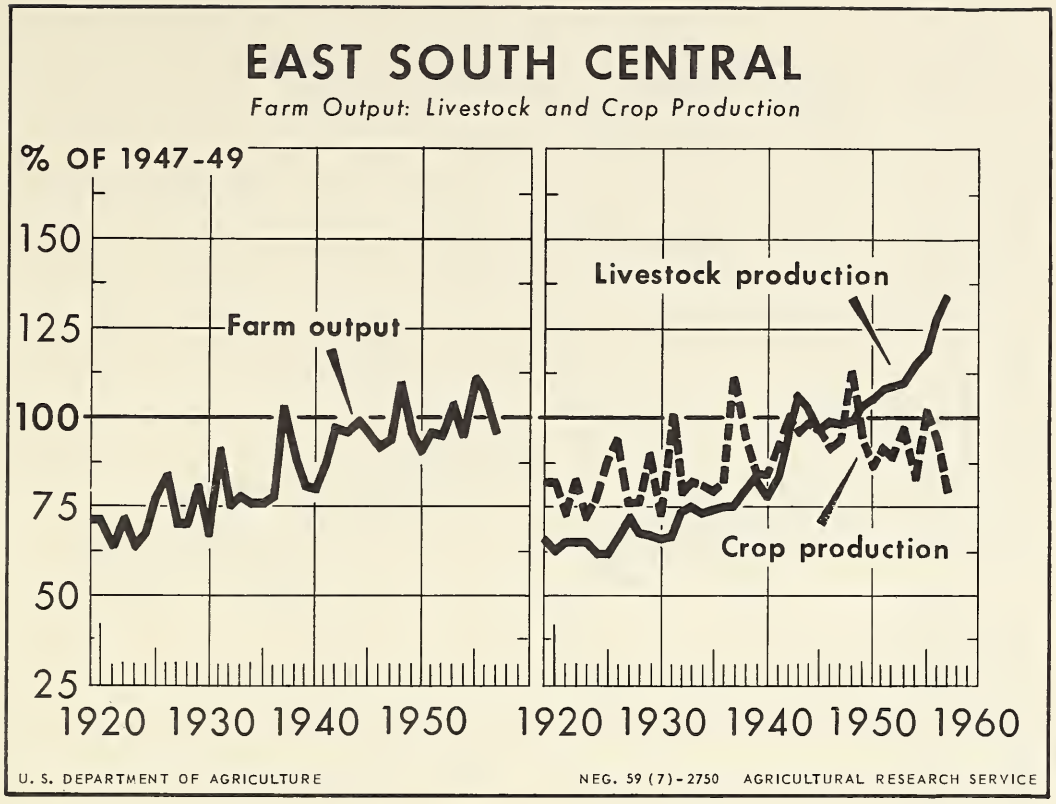

Figure 12.--In the east south-central region, the trend in farm output has been generally upward with wide annual fluctuations.

TABLE 27.--Annual changes in index points of crop production per acre, by source of change, east south-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre	0.45	1.86
Source of change:[2]		
Composition	-.11	-.63
Weather	-.08 to -.12	1.10 to 1.14
Specified yield-affecting practices[3]	.24 to .28	.72 to .76
All other	.38 to .42	.61 to .65

[1] Includes Kentucky, Tennessee, Alabama, and Mississippi.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

did not increase during the interwar period. Together, the less favorable growing conditions and the shift to less intensive crops had a negative influence on the average crop outturn per acre that was large enough to more than offset the increase, owing to yield-affecting practices and all other factors (table 29). The strong negative effect that crop production per acre had on the volume of farm output did not offset the upward push that came from the change in acreage of cropland. Livestock production contributed 10 percent to the addition to total output.

Crop production per acre in the west south-central region tends to have greater

TABLE 28.--Annual changes in index points of farm output, by source of change, west south-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.44	69	0.60	93	0.43	15	0.55	47
Change in product added by all livestock..	.03	5	.32	50	.40	14	.34	29
Change in pasture consumed by all livestock.....	.04	6	-.10	-16	.09	3	-.06	-5
Change in cropland used.....	.42	66	-.84	-131	.11	4	-.61	-52
Change in crop production per acre.....	-.29	-46	.66	104	1.83	64	.95	81
Total change in farm output.....	.64	100	.64	100	2.86	100	1.17	100

[1] Includes Arkansas, Louisiana, Oklahoma, and Texas.

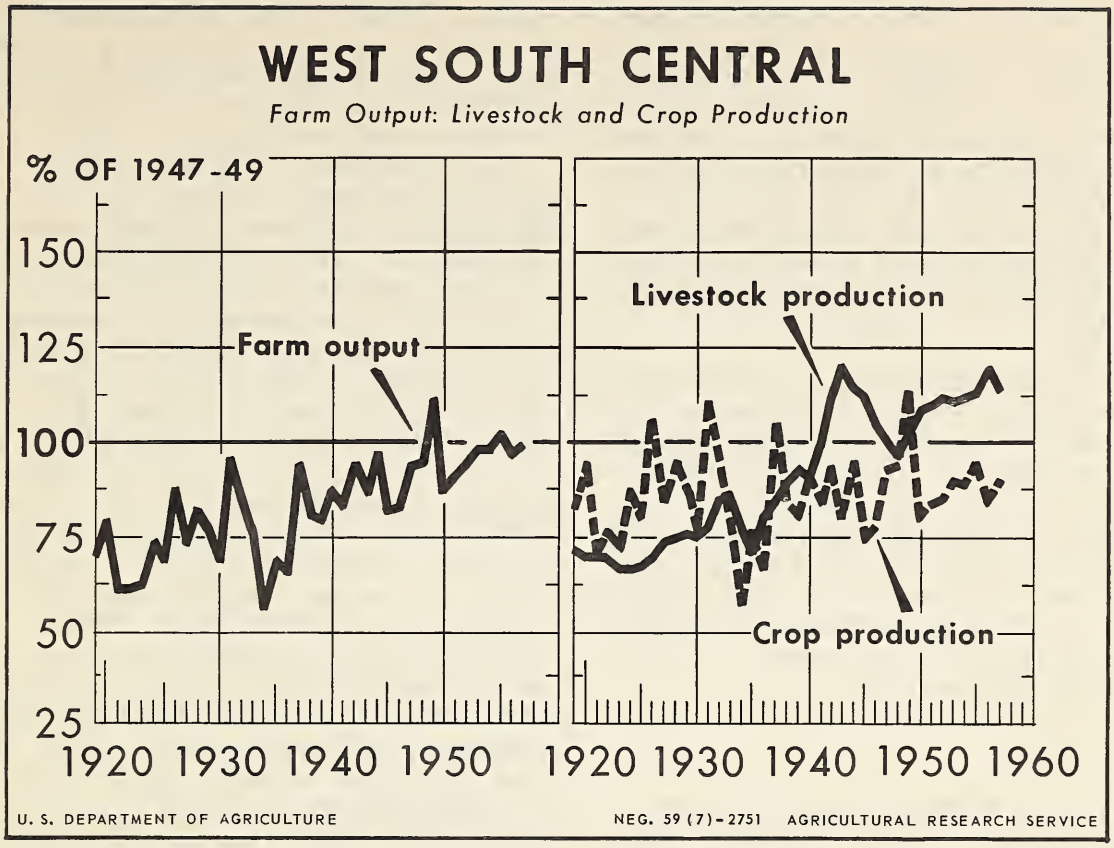

Figure 13.--Crop production tends to fluctuate more in the west south-central region than in any other region.

TABLE 29.--Annual changes in index points of crop production per acre, by source of change, west south-central region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre.....	-0.29	0.95
Source of change:[2]		
Composition.....	-.33	-.20
Weather.....	-.32 to -.36	.41 to .45
Specified yield-affecting practices[3].....	.03 to .07	.44 to .48
All other.....	.31 to .35	.24 to .28

[1] Includes Arkansas, Louisiana, Oklahoma, and Texas.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

annual fluctuations than in most other regions. Weather plays a dominant role in these fluctuations. Average annual rainfall ranges from 10 to more than 50 inches. Thus, in much of the nonirrigated part of the area, average rainfall is not much greater than the minimum amount required to raise such field crops as wheat and cotton. A slight change in rainfall, either above or below the average, makes the difference between a large or a small crop outturn per acre.

Farm output in the west south-central region increased by 20 percent during the World War II and recent periods. Larger crop production per acre, which was nearly a fourth more in 1955 than in 1940-41, was

the leading source of the increase in output in contrast to its negative effect in the previous period. Greater use of fertilizer and irrigation was chiefly responsible (table 29). Weather was more favorable at the end than at the beginning of the period and contributed about as much to the increase as did added fertilizer and irrigation. Composition continued to have a negative effect, chiefly because of Government programs, which reduced the acreage of cotton by 2.4 million acres.

Numbers of horses and mules decreased as much during the 15 years following 1940 as during the previous 20 years but dropped from first to second place in relative importance as a source of additional output. The acreage of cropland decreased by 15 percent and offset the gains in farm output that came from reduction in farm-produced power. The relative importance of livestock production in upping farm output increased greatly during this period.

Western Division

In the western division, which comprises the mountain and Pacific regions, farm output has increased rapidly since World War I. Greater total crop production from increased acreage and more production per acre have been the major contributing factors. Total livestock production also has increased rapidly.

The mountain region had the second greatest regional increase in farm output during the interwar period, when it increased by more than 40 percent, or about 1.2 index points per year (table 30). Reduction of farm-produced power was the leading source of the step-up in farm output (fig. 14). During this period, the number of horses and mules decreased by more than a million head. Use of more cropland was a close second in importance as a source of the greater farm output. The acreage of cropland used for crops increased by a fifth and was responsible for a third of the change in output. Stepped-up crop production per acre contributed a fifth.

The increase in crop production per acre during the interwar period was due to factors other than yield-affecting practices, weather, and composition (table 31). The less favorable weather at the end than at the beginning of the period had a lowering effect on output. The less intensive use of cropland also had a negative effect. This

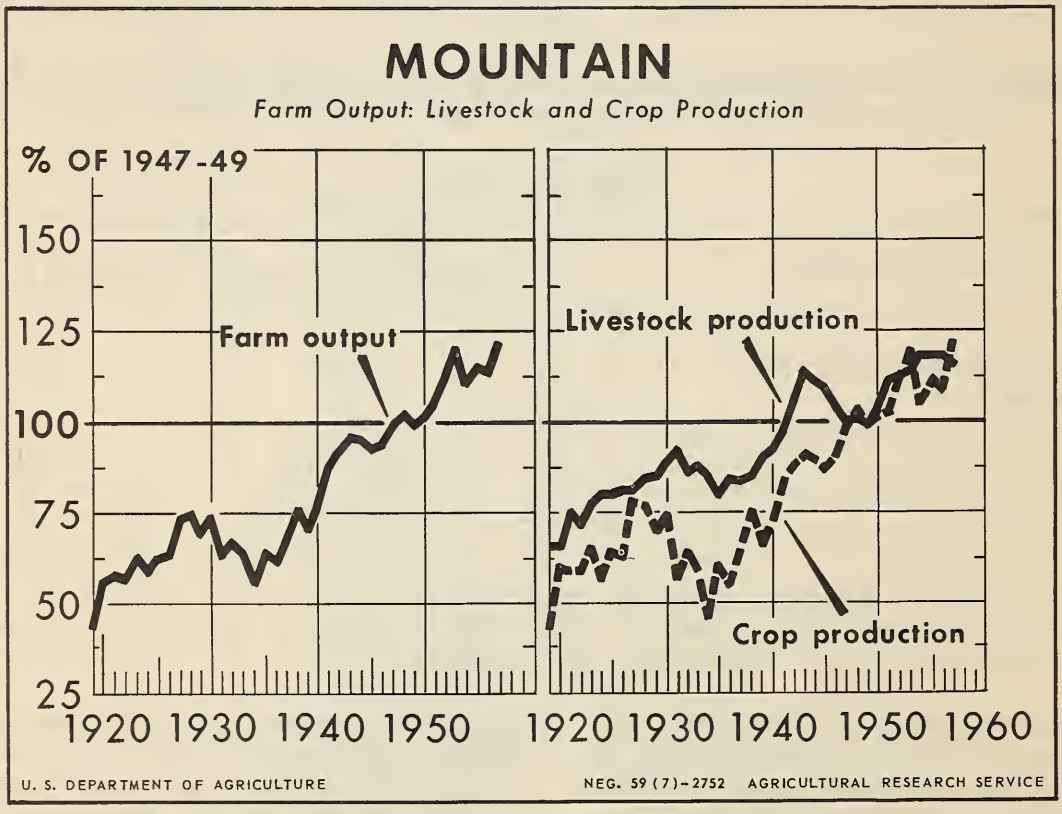

Figure 14.--In the mountain region, farm output has increased rapidly except for the depression and drought periods of the 1930's.

TABLE 30.--Annual changes in index points of farm output, by source of change, mountain region, specified periods 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.41	35	0.36	15	0.24	12	0.32	14
Change in product added by all livestock..	.07	6	.28	12	.48	24	.34	15
Change in pasture consumed by all livestock.....	.07	6	-.05	-2	.20	10	.02	1
Change in cropland used.....	.38	33	1.84	78	.30	15	1.44	63
Change in crop production per acre.....	.23	20	-.07	-3	.78	39	.16	7
Total change in farm output.....	1.16	100	2.36	100	2.00	100	2.28	100

[1] Includes Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada.

TABLE 31.--Annual changes in index points of crop production per acre, by source of change, mountain region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre	0.23	0.16
Source of change:[2]		
Composition	-.20	-.84
Weather	-.15 to -.19	.24 to .28
Specified yield-affecting practices[3]	.04 to .08	.23 to .27
All other	.52 to .56	.47 to .51

[1] Includes Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, and Nevada.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

can be attributed chiefly to increased use of summer fallowing. The yield-increasing effect of summer fallowing is included in the "all other" category of sources of change in farm output. Larger total crop production, the net result of increased acreage and crop outturn per acre, was responsible for half the additional output. Additional livestock production was responsible for little more than 10 percent of the increase.

During the 15 years after 1940, farm output in the mountain region increased at about the same percentage as it had during the previous 20 years. The greater acreage of cropland accounted for nearly two-thirds of the added farm output. Reductions in farm-produced power and increased livestock production each added about 15 percent.

Increased crop outturn per acre was of slight importance. The outturn increased more slowly than in the previous period, mainly because of the stepped-up use of summer fallowing, which caused a less intensive use of cropland. The acreage summer-fallowed increased from 4.5 million acres in 1940-41 to 10.2 million acres in 1955. Weather was more favorable in 1955 than in 1940-41. Increased use of hybrid seed corn, fertilizer, and irrigation helped to increase crop outturn per acre.

Farm output has increased faster in the Pacific region than in any other region in the United States. During the interwar period, an increase of two-thirds occurred in farm output (fig. 15). Stepped-up crop production per acre was by far the leading source of the added farm output; it accounted for nearly two-thirds of the change (table 32). An important source of the increased per acre outturn was the shift to the production of intensive crops (table 33). Acreages of such high-value crops as cotton, vegetables, and fruits were increased, while the acreage of grain crops was decreased. As a source of stepped-up crop output, irrigation was as important as fertilizer. During the two decades following 1920, the acreage of irrigated land in farms in the Pacific region increased by more than 35 percent, or 1.5 million acres. The acreage of cropland remained relatively stable and thus had little effect on the change in farm output. Livestock production, in the form of product added and pasture consumed, was the second major source of change in farm output. The reduction of farm-produced power contributed little more than 10 percent to the rise in farm output compared with 50 percent for the United States as a whole, largely because farm-produced power made up a much smaller proportion of the total production in the Pacific than in the other regions in 1919-21.

During the 1940-41 to 1955 period, farm output was stepped up by more than 45 percent. Crop production per acre increased by 25 percent; it continued to be the leading source of change. Yield-affecting practices accounted for most of this increase. The acreage of irrigated farmland increased from 5.8 million acres in 1940 to 9.3 million in 1954. Again, irrigation was about as important as fertilizer as a source of added crop outturn. Crop composition, which was an important factor during the previous period, did not contribute to the change in farm output between 1940-41 and 1955. The

TABLE 32.--Annual changes in index points of farm output, by source of change, Pacific region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change, 1919-21 to 1938-40		Change, 1940-41 to 1951-52		Change, 1951-52 to 1955		Change, 1940-41 to 1955	
	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total	Index point	Percentage of total
		Percent		*Percent*		*Percent*		*Percent*
Reduction in farm-produced power.....	0.18	11	0.15	5	0.10	6	0.13	5
Change in product added by all livestock..	.24	15	.47	16	1.01	59	.60	23
Change in pasture consumed by all livestock.....	.07	4	0	([2])	.24	14	.08	3
Change in cropland used.....	.11	7	.81	28	-.05	-3	.60	23
Change in crop production per acre.....	1.03	63	1.48	51	.41	24	1.21	46
Total change in farm output.....	1.63	100	2.91	100	1.71	100	2.62	100

[1] Includes Washington, Oregon, and California.
[2] Less than 0.5 percent.

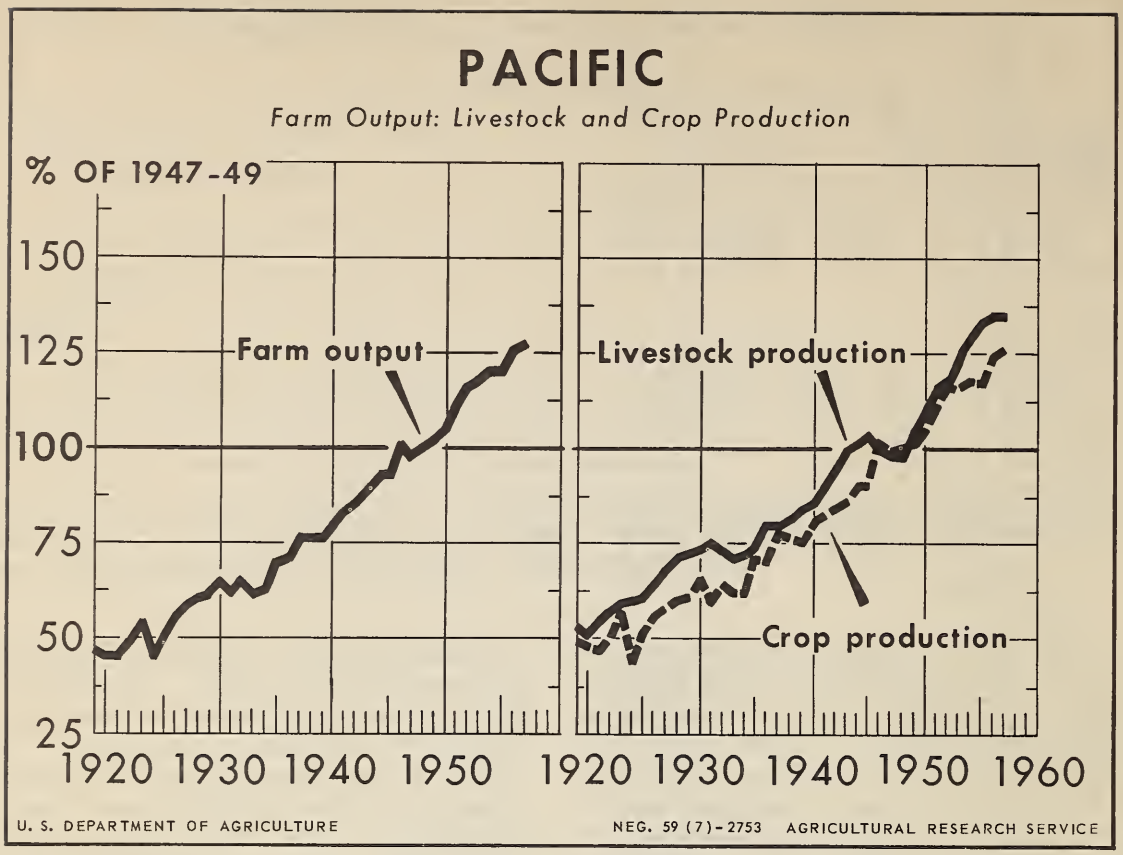

Figure 15.--The Pacific region has had the greatest and most persistent increase in farm output of any region.

TABLE 33.--Annual changes in index points of crop production per acre, by source of change, Pacific region, specified periods, 1919-55[1]

(1947-49 = 100)

Source of change	Change 1919-21 to 1938-40	Change, 1940-41 to 1955
Change in crop production per acre.....	1.03	1.21
Source of change:[2]		
Composition.....	.30	-.01
Weather.....	.04 to .08	.31 to .35
Specified yield-affecting practices[3].....	.12 to .16	.56 to .60
All other.....	.51 to .55	.29 to .33

[1] Includes Washington, Oregon, and California.
[2] Changes due to weather, practices, and "all other," probably fall within ranges shown.
[3] Includes hybrid seed corn, fertilizer, and irrigation.

relative importance of cropland as a source of changes in output increased during this period. Changes in crop production per acre and in cropland together contributed 70 percent of the greater farm output. The relative importance of livestock production increased; it accounted for over a fourth of the change.

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APPENDIX

Throughout this analysis, each source of change in farm output was estimated for each census region. With one exception, the contribution from a particular source for the United States as a whole was the sum of the estimates by regions. This exception was the change in United States crop production per acre that was due to shifts in the acreage of cropland between regions.

Components of Farm Output

Farm output may be divided into several components, and the quantity-price aggregate of total farm output may be computed in several ways.[10] For convenience, farm output was computed by summing (1) total crop production minus hay seed, grass seed, and cover-crop seeds, plus (2) product added by all livestock including horses and mules, plus (3) pasture consumed by all livestock including horses and mules. From the total of the three previous items, farm-produced power was subtracted (table 34). It was assumed that with a reduction in farm-produced power, the product added and the pasture and feed consumed by other livestock increased. In effect, a reduction of farm-produced power brought about a transfer of resources formerly used by horses and mules to the production of agricultural products for eventual human use. Thus, by constructing farm output in this way and assuming the reduction of farm-produced power to be a transfer item, the contribution to the change in farm output coming from total crop production, product added, pasture, and farm-produced power was determined by measuring the absolute change in each item.

[10] For the different methods of combining the components of agricultural production to compute farm output, see U. S. Dept. Agr. Handb. No. 118 (10).

Change in Total Crop Production Associated with Shifts in Acreage of Cropland and in Crop Production per Acre

The total volume of crop production may change from one period to another because of shifts in the number of acres of cropland used and changes in crop production per acre. The problem is to divide the increase in crop production into the portions associated with these factors. There are several possible plus and minus combinations of the factors.

The method of Mills (2) was used for measuring the relative importance of labor productivity and labor inputs in the change in gross national product (GNP).

Three steps were taken in dividing the increase in crop production between two periods into the two overall factors. These were:

(1) The portion associated with pure change in acreage of cropland used for crops was estimated.

(2) The portion associated with pure change in crop production per acre was estimated.

TABLE 34.--Change in sources of increased farm output for the United States, 1940-41 to 1955[1]

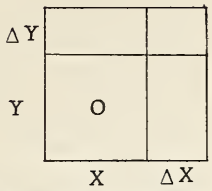
Component	Period 1 1940-41	Period 2 1955	Change
	Million dollars	*Million dollars*	*Million dollars*
Crop production minus grass seeds	16,775	20,605	3,830
Product added by all livestock[2]	6,290	8,152	1,862
Pasture consumed by all livestock[2]	1,881	2,039	158
Farm-produced power[3]	-2,341	-612	[4] 1,729
Farm output	22,605	30,184	7,579

[1] Measured in 1947-49 dollars.
[2] Includes horses and mules.
[3] Not included in farm output.
[4] A reduction in farm-produced power would increase farm output.

(3) The portion associated with the interaction component--the change in production per acre combined with the change in acreage--was estimated.

The accompanying diagram shows how this procedure operates:

Let X = acres of cropland used in period 1 (base period).
X + Δ X = acres of cropland used in period 2 (given period).
Y = crop production per acre in period 1 (base period).
Y + Δ Y = crop production per acre in period 2 (given period).
O = XY = total crop production in period 1.



Δ O = (Δ X Y) + (X Δ Y) + (Δ X Δ Y) = change in total crop production in period 2 from period 1.
O + Δ O = (X + Δ X) (Y + ΔY)=total crop production for period 2.

From this diagram, the increase in crop production associated with the pure change in number of acres of cropland used for crops is equal to Δ XY. The increase in production associated with the pure change in crop production per acre is equal to X Δ Y.

The interaction of these two factors is equal to Δ X Δ Y. Assuming that X and Y change linearly between periods 1 and 2, half of the interaction is associated with the change in acreage of cropland and half with the change in crop production per acre.

The total change in crop production associated with shifts in cropland used for crops may be expressed as $\Delta XY + \frac{\Delta X \Delta Y}{2}$ and the change associated with a shift in crop production per acre may be expressed as $X \Delta Y + \frac{\Delta X \Delta Y}{2}$.

Measuring Factors Responsible for Change in Crop Production per Acre

The contribution of crop production per acre to the change in total crop production, as measured in the previous section, is the "net" effect of all factors associated with the change in production per acre. In this analysis, the contributions of changes in acreage composition, weather, fertilizer, irrigation, hybrid corn, and all other sources of change in crop production per acre, were measured individually. No attempt was made to measure the statistical interaction between sources. Even with the aforementioned weakness, a wide change in the results obtained would affect the relative importance of the individual source of change in crop outturn per acre very little. The methodology used to measure the relative importance of sources of change in aggregate crop production per acre is explained in the following sections.

Composition

As shown in the analysis of preceding sections, changes in acreage composition, or the crop-mix of intensive and extensive crops, can have an important effect on changes in aggregate crop production per acre. With other things held constant, shifts to intensive crops (crops of higher than average value per acre) will tend to increase average production per acre. It is possible that a crop may have a higher than average value per acre in one region and a less than average value in another. Thus, an increase in the proportion of total acreage planted to the crop in one region may increase aggregate value per acre in that region. In another region, the opposite may be true. For example, the value of corn per acre is greater than the average crop value per acre in the west north-central region but is below average in the south Atlantic region.

To measure the effect of changes in composition, yields and total acreage of crops planted were held constant; thus, only the relative proportion of total cropland planted to individual crops was allowed to change. In brief, the procedure used is as follows:

(1) For both the beginning and ending periods, the total acreage planted was divided into the acreage devoted to each crop group.
(2) The percentage distribution of total acreage, by crop groups, was calculated.
(3) The yield per planted acre for each crop was calculated.
(4) The yields per planted acre of crops grown in each period were weighted by the acreage distribution in the opposite period (period 1 yields weighted by period 2 acreage distribution and period 2 yields by period 1 acreage distribution).
(5) The actual average crop production per acre in period 1 was subtracted from the adjusted crop production per acre.
(6) The adjusted average crop production per acre in period 2 was subtracted from actual production per acre.
(7) The average of the two previous steps measures the effect that composition has on the shift in crop production per acre. Multiplying this figure by the number of acres in period 2 gives the effect of composition on the total change in crop production.

Crop production per acre usually changes because of shifts in acreage and changes in yield per acre of individual crops. Table 35 shows a hypothetical example in which yields of individual crops increased and acreage composition tended to shift from crops of low value per acre to those of higher value, but the total acreage planted remained unchanged. In period 1, the average production per acre was $37.25, but if the acreage composition of period 2 had

TABLE 35.--Change in crop production per planted acre, owing to shifts in acreage composition and yields per acre[1]

Crop	Period 1				Period 2			
	Acreage planted	Acreage distribution	Value of yield per acre planted	Yields weighted by period 2 acreage distribution	Acreage planted	Acreage distribution	Value of yield per acre planted	Yields weighted by period 1 acreage distribution
	Acres	*Percent*	*Dollars*		*Acres*	*Percent*	*Dollars*	
1.....	1,000	10	90.00	13.50	1,500	15	120.00	12.00
2.....	2,500	25	45.00	9.00	2,000	20	55.00	13.75
3.....	1,500	15	30.00	7.50	2,500	25	35.00	3.75
4.....	5,000	50	25.00	10.00	4,000	40	30.00	15.00
Total or average.....	10,000	100	37.25	40.00	10,000	100	49.75	44.50

[1] Hypothetical data were used to illustrate the procedure used.

prevailed, the average crop outturn per acre would have been $40.00. However, the actual production per acre in period 2 was $49.75, compared with $44.50 if the acreage composition of period 1 had prevailed. Increased yields per acre in period 2 caused composition to have a greater effect on the average crop outturn per acre in that period than in period 1. To allow for the statistical interaction between shifts in acreage composition and changes in yields, the differences between the actual and computed production per acre for each period were averaged together. Thus, of the $12.50 ($49.75 - $37.25) increase in actual production per acre, $4.00 or $\frac{(\$2.75 + \$5.25)}{2}$ was due to shifts in crop mix.

Shifts in the proportion of total cropland between regions also may increase or decrease average United States production per acre. For example, if the total acreage of cropland increased faster in regions with crop production per acre lower than the average for the United States, the average United States production per acre would decrease even though yields of individual crops remained constant. Obviously, this would not be a factor for the change in regional crop production per acre.

In measuring the importance of the relative shifts of cropland between regions, the method used was the same as that used to compute the change caused by shifts in crops grown within regions.

Weather

Fluctuations in average year-to-year crop production per acre are due chiefly to weather and such weather-associated factors as diseases and insect pests. Changes in technology are important also, but they tend to move gradually from one year to the next.

Major crops in each region were considered separately in measuring the effects of weather on changes in average crop production per acre. In all instances, the total production of the crops considered accounted for 75 percent or more of the total crop outturn of the region. A regression line was fitted to historical yields of each crop. It was assumed that the regression line would measure the changes in technology under average weather. Some crops show changes in yield trend over time; in these instances, regression lines were computed for more than one period. It was assumed that if the actual yield in a given year were greater than the trend yield, the weather was better than average. The opposite was assumed if actual yields were below the trend line.

By means of these assumptions, yields of each specified crop were adjusted at the ending period to the same level above or below the regression line as it was at the beginning. The adjusted yield for each crop was subtracted from the actual yield. This difference was attributed to the effect of weather on the change in yield per acre. The weighted average change between actual and adjusted yield per acre of specified crops was used as a measure of effect of changes in weather on aggregate production per acre of all crops. These estimates followed closely weather reported by the Crop Reporting Board.

Figure 16 shows the yield of cotton in the West South Central States from 1919 to 1957, with the regression line computed. By using the methods described above, weather averaged better in 1919-21 than in 1938-40, much below average in 1951-52, and far above average in 1955. Thus to estimate the effect of weather on changes in cotton yields in the west south-central region from 1919-21 to 1938-40, the average 1938-40 yield was adjusted upward to the same level above the regression line as in 1919-21. The adjusted yield was then subtracted from the actual yield. As the adjusted yield was greater than the actual yield, less favorable weather in 1938-40 had a lowering effect on cotton yields compared with those of the earlier period. The opposite would be the case if the 1955 yield were compared with the 1951-52 yield.

Fertilizer

The use of fertilizer has increased rapidly since the end of World War I. Increased use of fertilizer is usually accompanied by increased use of such practices as greater plant population and better use of available moisture.

To estimate the contribution of fertilizer to the increase in crop production per acre, a marginal-return approach was used. The marginal return to corn production with 1954 fertilizer practices for the United States as a whole has been reported as $3.06. By regions, it ranges from $1.38 to $3.78 (1). Further preliminary research indicates that in some parts of the country, certain crops have a return of as much as $5.00 for each $1.00 spent for fertilizer.

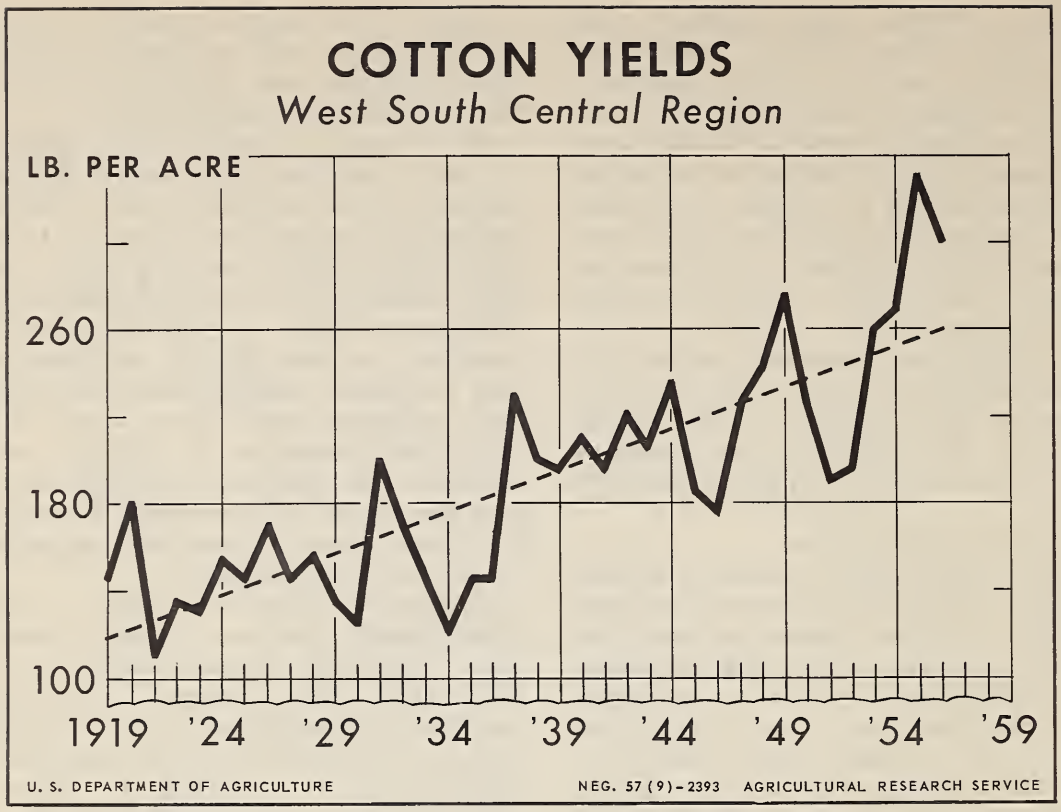


Figure 16.--Weather was assumed to be better than average when cotton yields were above the trend line and less than average when yields were below.

The 1954 Census of Agriculture reported that fertilizer was used on a little more than a fourth of the cropland in the United States. This indicates that, in general, fertilizer has not been used to the point at which marginal returns are equal to the cost of the fertilizer used.

There is evidence that an increasing amount of fertilizer has been used on pastureland. But in this analysis, all fertilizer was assumed to have been used for crop production other than pasture. Since the census reported that of all fertilizer used in 1954 only 3 percent was used on improved pastures, the assumption does not affect seriously the estimate of the contribution of fertilizer to increased crop production per acre.

Total fertilizer used was measured in constant dollars by means of the same weight periods that were used in calculating the quantity price aggregates of farm output. Based on some preliminary fertilizer studies in the Corn Belt with adjustments made for complementary production inputs, regional marginal ratios were varied from 1.5:1.0 to 3.5 :1.0. That is, for each additional constant dollar of fertilizer used per acre over a given period, the value of crop production per acre was assumed to increase by $1.50 to $3.50. The marginal-return ratio was varied by regions, chiefly on the basis of how extensively fertilizer had been used historically. The regions along the Atlantic Coast, where the fertilizer industry had its beginning, were the regions for which smaller marginal returns were used. These assumptions are probably close to the minimum contribution of fertilizer.

In brief, the steps used in estimating the contribution to crop production per acre of greater use of fertilizer are as follows:

(1) Measure the total fertilizer used in constant dollars for each of the nine census regions for the various periods.

(2) Compute the average amount of fertilizer used per acre of cropland in periods 1 and 2.

(3) Calculate the difference in the rates of fertilizer used per acre of cropland.

(4) The result of step "3," multiplied by the marginal-returns ratio for the region, gives the amount of added crop production per acre that was due to fertilizer.

Hybrid Corn

Corn accounts for nearly a fourth of the total crop production in this country. Therefore, changes in production of corn influence greatly aggregate crop production per acre.

It is estimated that the greater vigor of hybrids, and their resistance to lodging, plant diseases, and insects, increase per acre yields about 20 percent over those of open-pollinated varieties. The completeness of data on the production of corn by States makes possible a fairly accurate calculation of the effect of hybrid seed corn in each year, if a 20-percent increase in yield is assumed.

In this analysis, total production of corn was measured in constant dollars as was farm output. By using the algebraic formula-

$AB + A^1B^1$ = total corn production, in which
- A = acres of open-pollinated corn planted
- A^1 = acres of hybrid corn planted
- B = yield of open-pollinated corn
- B^1 = yield of hybrid corn (1.2B)

the difference in yields resulting from use of hybrid seed can be computed for any given year. The added production from hybrid seed in periods 1 and 2 is computed and the average increase in production per acre planted is found. In estimating the contribution of greater use of hybrid seed to additions to crop production, this difference between the average return per acre planted due to hybrid seed was computed and multiplied by the acreage planted in period 2.

Irrigation

Irrigation has been an important source of greater crop production in much of the Western farming area.

In this analysis, the contribution of irrigation refers to the increased production that comes from adding water to cropland. Increased use of irrigation usually is accompanied by increased use of such inputs as fertilizer, plant population, herbicides, and insecticides. After studying several irrigation reports, the cost of these additional inputs above the cost of delivering water was subtracted out when measuring the contribution of irrigation to the stepped-up crop output per acre. By this method, it was estimated that in the regions east of the Mississippi River, where sprinkler irrigation predominates, irrigation would increase crop production per acre by an average of 30 percent compared with yields on nonirrigated land. But in regions west of the Mississippi, where rainfall is limited, irrigation would increase crop production per acre 50 percent over dryland production. The acreage data used are the reported irrigated acreages minus the acreages of irrigated pastureland. The source of acreage data is the census of agriculture.

The 1955 Yearbook of Agriculture (9) reports that a reasonable overall estimate of the contribution of irrigation to increased yields per acre appears to be from 25 to 50 percent. The President's 1950 Water Resources Policy Commission (3) also reported that, on the average, crop production per acre would increase 50 percent from the use of irrigation. These reports appear to justify the assumptions used for the effect of irrigation east and west of the Mississippi River.

By using an algebraic formula similar to the one used to compute yields from open-pollinated and hybrid corn seed, the average crop production per acre for both irrigated and nonirrigated crops was computed in period 1. In estimating the contribution of irrigation to the change in crop production, the difference between the two was multiplied by the change in the acreage irrigated between periods 1 and 2.

All Other

The "all other" category is the residual left after subtracting the total contribution of the individual factors measured from the change in crop production per acre. Consequently, this category would include any interaction not taken into account in measuring the individual sources of increase, plus all other sources of increase in crop production per acre. These other sources would include such practices as liming, conservation practices, land selectivity, herbicides, and insecticides.

The importance of this category to increased crop production per acre seems reasonable when compared with the individual sources measured. For example, as more than 70 percent of the 1955 cropland was planted to varieties of seed not in existence only 20 years earlier, improved seed varieties no doubt contributed much more to greater production per acre than did hybrid corn seed alone.

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